Mortgage Interest Deductions? Not a Bad Idea After All[★]

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Abstract

Mortgage interest deductions and other homeownership subsidies are widely believed to be harmful because they redistribute resources from lower-income renters to higher-income homeowners. We argue that renters actually benefit from these policies in general equilibrium for two reasons. First, the rental supply curve is relatively inelastic, which means that rents fall when these policies reduce rental demand. Second, many renters spend most of their income on housing, and these renters gain substantially from rent decreases. We calibrate a quantitative model to match empirical evidence on these factors and show they are strong enough that subsidizing homeownership actually increases welfare.

Keywords: Mortgage interest deduction, rental supply elasticity, rent-to-income ratio, homeownership, welfare
JEL: R21, R31, H20

1. Introduction

Promoting homeownership is a cornerstone of economic policy in the United States and many other countries. The U.S. government subsidizes homeowners in a variety of ways, but the most well known subsidy is the mortgage interest tax deduction (MID). The consensus in the literature is that the MID and other homeownership subsidies are harmful because they redistribute resources from renters, who tend to have low incomes, to homeowners, who tend to have high incomes. We argue that renters actually benefit from these policies in general equilibrium because they reduce demand for rental housing, which in turn reduces market rents. The importance of this effect is determined by two key factors: the price elasticity of the rental housing supply, which determines how sensitive rents are to changes in rental demand, and the number of renters who spend the majority of their income on housing and are thus substantially affected by changes in rents. We

[★]Data and Replication code are available on Github at www.github.com/srotberg/Mortgage-interest-deductions-Not-a-bad-idea-after-all-.

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show that in an otherwise-standard quantitative housing model calibrated to match the empirical evidence on these factors, the MID and other homeownership subsidies are actually beneficial, especially for low-income renters.

Numerous studies have analyzed the welfare consequences of the MID and other homeownership subsidies, such as the preferential tax treatment of imputed rents generated by owner-occupied housing. Gervais (2002), Floettoto et al. (2016), and Nakajima (2020) find that eliminating both of these subsidies would increase welfare, and further work by Chambers et al. (2009), Sommer and Sullivan (2017), and Karlman et al. (2021) report welfare gains from eliminating the MID.[1] The economic logic behind these findings is straightforward and appealing: homeowners are richer than renters on average, so tax policy ought to redistribute resources from the former to the latter, not the other way around. However, we argue that these studies understate the extent to which homeownership subsidies reduce rents in equilibrium and the importance of this effect for renters' welfare. In some, the price elasticity of rental housing supply is higher than in the data, which means that rents do not respond much in equilibrium to changes in rental demand. In others, there are fewer renters who spend the majority of their income on housing than in the data, which means that changes in rents do not have large effects on renters' welfare. Table 1 provides an overview of these studies, their assumptions, and their findings.

We calibrate a dynamic general-equilibrium model to match empirical evidence on the rental supply elasticity and the distribution of rents relative to income, and simulate the effects of repealing the MID and taxing imputed rents. Our results confirm that the way rental prices, and thus renters, are affected in equilibrium plays an important role in determining these policies' overall welfare implications. In our calibrated model that matches both pieces of evidence, the general-equilibrium effects are strong enough that removing these subsidies would actually reduce welfare. However, when our model is calibrated to match either one but not the other, welfare would increase, as previous studies have found. Thus, capturing both features of the data is crucial to getting the general-equilibrium effects right. [2]

The rental housing supply elasticity is important because it determines how much rents change in equilibrium when demand for rental units shifts. Many studies in the quantitative housing literature simply assume the rental supply is perfectly elastic, which means that rents are completely independent of demand (see, e.g., Gervais, 2002; Kaplan et al., 2019; Karlman et al., 2021). Other studies use models in which rental housing is supplied endogenously by households that choose to act as landlords, but the aggregate rental supply curve in these models is still highly elastic (see, e.g., Floettoto et al., 2016; Sommer and Sullivan, 2017).[3] We propose a new approach to

[1] Floettoto et al. (2016) and Karlman et al. (2021) report short-run welfare losses in some experiments. Our focus is on the long run, where all of these studies agree.

[2] This conclusion may apply to other policies that affect rental prices in equilibrium as well as homeownership subsidies. For example, Rotberg (2022) studies wealth taxes in a quantitative housing model with an infinite rental supply elasticity. He finds that wealth taxes that apply to housing as well as financial assets are harmful because they are passed on to renters in equilibrium in the form of higher rental prices. We speculate that with a realistically low rental supply elasticity, renters would largely be insulated from the effects of wealth taxes.

[3] The sole exception is Chambers et al. (2009), whose model features a realistically low supply elasticity but still predicts that removing the MID would be optimal because it does not match the number of cost-burdened renters. Our study shows why matching both the supply elasticity and the share of cost-burdened renters is crucial for accurately

identify this parameter in structural models using evidence on how rents respond to changes in property taxes. The economic intuition behind this approach is that the more elastic the supply, the greater the share of property taxes borne by renters. The Institute on Taxation and Economic Policy (ITEP) reports that renters pay about 50% of property taxes in the United States (Wiehe et al., 2018). This estimate yields a long-run rental supply elasticity of 1.4 in our model, which implies that removing the MID would actually increase rents far more than predicted by previous studies that use models with much higher elasticities. Another study that structurally estimates the rental supply elasticity is Greenwald and Guren (2021), who identify it using the responses of homeownership and the price-rent ratio to transitory credit shocks. Like us, they find that this elasticity is low—in fact, their estimate is close to zero in the short run—but they focus on the implications of this finding for house price volatility in the short run rather than housing policy in the long run.

The number of renters who spend the majority of their income on rent—defined as "severely cost-burdened" according to the U.S. Department of Housing and Urban Development (HUD)—is important because it determines the welfare consequences of changes in rents. Using data from the 2019 Survey of Consumer Finances (SCF), we find that 15.1% of renters in the United States are severely cost-burdened. We use this statistic to identify the minimum allowable size of a rental dwelling in our model, which we find to be about 40% of the average owner-occupied house size. In comparison, many quantitative studies of housing policy have no lower bound on rental housing size (see, e.g., Chambers et al., 2009; Floettoto et al., 2016; Nakajima, 2020). In these models, renters spend less of their income on housing and can respond to rent increases by downsizing further, which implies that changes in rents have smaller welfare effects. Other studies do not report how this parameter is chosen at all (see, e.g., Sommer and Sullivan, 2017; Karlman et al., 2021). The minimum rental size is a real-world constraint imposed by many jurisdictions, not just a model ingredient that is useful for generating a realistic rent-to-income distribution. For example, New York City zoning law requires rental apartments to be at least 300 square feet.[4]

Our model is populated by overlapping generations of households that are heterogeneous in labor productivity, financial wealth, housing tenure, and mortgage debt. Households supply labor inelastically and are taxed progressively on their earnings as in Heathcote et al. (2017). They obtain housing services by renting or buying a home. Rental housing is provided by a competitive rental company, as in Chambers et al. (2009). Home purchases can be financed with long-term mortgages. Households can deduct mortgage interest payments from their taxable income, as allowed by the U.S. tax code. Most importantly for our purposes, there is a minimum allowable rental unit size and the cost of managing rentals is convex. We calibrate our model so that it reproduces salient facts about demographics, income dispersion, public finances, and housing markets. Several of our housing-related target statistics are standard in the quantitative housing literature: the maximum leverage ratio, the mortgage interest premium, property taxes and transaction costs, the homeownership rate, and the rent-price ratio. We add two new targets that capture the key features of the rental market discussed above: the share of property taxes borne by renters, which identifies the convexity of the rental management cost and thus determines the rental supply elas-

quantifying the consequences of housing policy.

[4] See https://zr.planning.nyc.gov/article-ii/chapter-3/23-23.

ticity; and the share of renters who are cost-burdened, which identifies the minimum rental size.

We use our model to analyze the macroeconomic and distributional consequences of MID repeal and the introduction of a tax on imputed rents. In order to assess the role of the rental supply elasticity and the share of cost-burdened renters, we conduct each experiment in three different calibrations of our model: the benchmark calibration that matches the evidence on both factors; a calibration with an infinitely-elastic rental supply that still matches the number of cost-burdened renters; and a calibration without a lower bound on rental size that still matches renters' property tax incidence. In our benchmark calibration, both tax reforms would increase rents and reduce welfare. In the infinite-elasticity calibration, both reforms would increase welfare because they would reduce rents. In this case, the equilibrium rent is independent of the quantity of rental housing supplied, so the decrease in home prices would cause rents to fall. Both reforms would also increase welfare in the no-minimum-rental calibration. Here, rents would rise as in the benchmark because the rental supply is inelastic, but this would inflict less pain on low-income renters because they are not constrained by a floor on housing consumption, and the benefits for other households would outweigh these smaller losses.

2. Key factors: empirical evidence and identification

The main finding of this paper is that homeownership subsidies benefit renters in general equilibrium and that there are two key factors that determine the magnitude of this effect: the price elasticity of the rental supply curve and the number of renters who spend most of their income on housing. Here, we discuss the empirical evidence on these factors, how we use this evidence to identify structural parameters in our model, and how our calibration compares to other studies.

2.1. Rental supply elasticity

The first factor that determines the consequences of homeownership policies is the price elasticity of the supply of rental housing. The steeper the slope of the rental supply curve, the more rents change in equilibrium when demand for rental housing shifts as a result of a change in the homeownership rate.

Panel (a) of Figure 1 provides a graphical illustration of this point. The x-axis represents the quantity of rental housing and the y-axis represents the per-unit rental price. The solid red line, S_1, depicts an elastic rental supply curve, and the solid blue line, S_2, an inelastic supply curve. Both supply curves slope upward because the marginal cost to provide rental housing is increasing due to span-of-control issues, financial frictions, increasing management costs, etc., but the marginal cost increases more quickly for S_2 than S_1. The black lines D and D' represent rental demand curves, which slope downward because marginal homeowners become renters and existing renters demand larger units when rents fall. These supply and demand curves show how the quantities demanded and supplied change with the rental price, holding everything else fixed, including house prices. Unlike changes in rents, which create movements along the curves, changes in house prices shift these curves up or down. For example, an increase in house prices would shift the supply curve down because it would increase the marginal cost to supply the same amount of rental housing. On the other hand, an increase in house prices would shift the demand curve up because it would make renting more attractive relative to homeownership holding fixed the rent price.

The diagram depicts a scenario in which demand is initially at D and the equilibrium rental price is $p_{r,0}$. Then, a policy change like removing the MID makes renting more attractive relative to homeownership, which causes rental demand to shift outward to D'. This causes the equilibrium rental price to rise to $p'_{r,1}$ under supply curve S_1 and to $p'_{r,2}$ under supply curve S_2. The key take-away from the diagram is that when rental demand shifts outward, rents rise more in equilibrium under an inelastic supply curve than under an elastic supply curve, i.e., $p'_{r,2} > p'_{r,1}$.

2.1.1. *Identification*

We propose a method to identify the rental supply elasticity using empirical evidence on the share of property taxes borne by renters. The gist of our identification strategy is that the slope of the rental supply curve determines how much rents change in equilibrium when the property tax rate changes.[5] If the supply were perfectly inelastic, rents would be independent of property taxes, and so renters' share of property taxes would be zero. At the other extreme, if the rental supply were perfectly elastic, rents would change one-for-one with the property tax rate, i.e., renters' share of property taxes would be 100%. In between these two extremes, the slope of the supply curve determines the extent to which changes in property taxes are passed on to renters.

Panel (b) of Figure 1 provides a graphical illustration of this identification. The axes are the same as in panel (a) of the Figure. As before, the solid red and blue lines, S_1 and S_2, show elastic and inelastic rental supply curves, respectively. The demand curve D is constant and the initial equilibrium price, $p_{r,0}$, is the same in both cases. The dashed red and blue lines, S'_1 and S'_2, depict how the elastic and inelastic supply curves shift after a property tax increase. The equilibrium price after this increase in the elastic case is labeled $p'_{r,1}$, and $p'_{r,2}$ is the new equilibrium price in the inelastic case. The share of the property tax increase borne by renters is calculated as the change in the equilibrium price divided by the vertical distance between the supply curve before and after the shift. The denominator in this expression represents the difference between the rental supplier's pre- and post-tax revenue. Because both supply curves shift upward by the same amount—the size of the tax increase—it is clear from the fact that $p'_{r,1} > p'_{r,2}$ that renters' tax incidence is higher when the rental supply curve is more elastic. To calibrate the rental supply elasticity in our model, we simulate a 1 percentage point increase in taxes on the value of rental property, compute the share of that increase borne by renters, and set the convexity of the rental management cost function so that this share is equal to its empirical counterpart.[6]

2.1.2. *Empirical evidence*

Panel (a) of Table 2 provides an overview of the empirical evidence on renters' share of property taxes. Early studies on this topic like Orr (1970) typically report shares of 40–50%, while the most recent study by Schwegman and Yinger (2020) estimates a lower share of only 14%. The Institute on Taxation and Economic Policy (ITEP), whose analysis of the U.S. tax burden distribution is widely relied upon by policy analysts, uses a value of 50% based on a meta-analysis of this

[5] The first-order condition (18) of the rental management company in our model provides a mathematical formalization of this logic.

[6] We provide a detailed description of our calibration algorithm in Appendix A.

evidence (Wiehe et al., 2018).[7] To be conservative, we use the ITEP's value, which implies a rental supply curve in our model that is moderately elastic, with an elasticity of 1.4. Lower property tax incidences estimated by more recent studies like Schwegman and Yinger (2020) would imply a highly inelastic supply curve that would make rents more sensitive to shifts in rental demand, which in turn would make renters benefit even more from homeownership subsidies.

Additional supporting evidence comes from studies on the extent to which rents respond to the provision of housing vouchers. The basic idea here is that the more elastic the rental supply curve, the less rents respond in equilibrium to a shift in rental demand caused by vouchers. Panel (b) of Table 2 provides an overview of empirical estimates of the effect of vouchers on rents. Although some early studies report small effects (see, e.g., Barnett, 1979), most recent studies like Susin (2002), Fack (2006), Gibbons and Manning (2006), Kangasharju (2010), Viren (2013), Collinson and Ganong (2018), and Sayag and Zusman (2020) estimate that landlords capture significant portions of voucher values. We view this as supporting evidence that the rental supply is far from perfectly elastic. It does not, however, provide direct evidence on the magnitude of the rental supply elasticity. Given an estimate of the effect of vouchers on rent, one would need additional information such as the income elasticity of demand and the voucher value relative to the average renter's income to infer the supply price elasticity.

One potential concern about these empirical estimates is that they might reflect short-run responses driven by adjustment costs and other frictions rather than long-run responses. We argue that this is not likely to be the case, and that our model's elasticity is appropriate for long-run analysis. The earlier studies of property tax incidence listed in panel (a) of Table 2 use cross-sectional specifications and identifying assumptions that imply a long-run interpretation.[8] The most recent analysis by Schwegman and Yinger (2020) uses a difference-in-difference approach, but their dataset covers a 13-year period after the reform they study, and their estimate is much lower than the target we use in our calibration.[9] Many of the voucher studies listed in panel (b) of Table 2 also cover long time horizons; Fack (2006) and Susin (2002), who report the highest estimates of the share of vouchers captured by landlords, study the longest time periods. As we discuss in Section 4.3 below, landlords capture 55% of vouchers in the long run in our calibrated model, which is exactly equal to the average empirical estimate found in the literature. This is an indication that our approach yields a reasonable estimate of the long-run rental supply elasticity.

Additionally, the evidence indicates that the short-run rental supply elasticity is likely much lower than the elasticity we use in our model. One piece of evidence comes from Trojanek and Gluszaks (2022), who analyze how the influx of Ukrainian refugees into Poland following the February 2022 Russian invasion affected Polish rental markets in the short run. They find that the populations of Warsaw and Kraków grew by 15% and 23%, respectively, raising rents by 14%

[7]One of the authors of Wiehe et al. (2018) informed us that they "assume…that half of the [property] tax is passed forward to the renter while the other half falls on the landlord. We are aware of studies finding pass-through percentages both higher and lower than this amount, but have concluded that this is roughly the midpoint estimate of the best available literature…In general, I think of our…assumptions as being long-term estimates."

[8]See England (2016): "most [of these studies] have taken a very long-run view of property tax incidence; these studies typically assume that labor is perfectly mobile across all jurisdictions…and that land is perfectly mobile among all uses…"

[9]Their dataset actually covers an even longer period 1975–1994, but the reform they study occurred in 1981.

and 16.5%. A back-of-the-envelope calculation suggests that these figures imply short-run rental supply elasticities of 0.4–0.7, which are between one-third and one-half of our model's elasticity.[10] Another piece of evidence comes from Greenwald and Guren (2021), who study the effects of transitory credit shocks on housing markets in the United States. They find that credit shocks have large effects on the ratio of house prices to rents but negligible effects on homeownership, which means that the supply of rental housing is almost perfectly inelastic in the short run.[11] Based on this evidence, we believe the rental supply elasticity we use in our analysis is more suited to analyzing the long run than the short run.

2.1.3. Previous quantitative studies

Previous quantitative studies have taken two approaches to modeling the supply of rental housing. The first is to model a representative rental management corporation. This approach has been used in a number of studies of the MID (see, e.g., Gervais, 2002; Nakajima, 2020; Karlman et al., 2021), as well as studies of other housing-related phenomena (see, e.g., Arslan et al., 2015; Kaplan et al., 2019). Almost universally, these studies assume that the rental supply is infinitely elastic. In the second approach, rentals are supplied by individual households that choose to act as landlords (see, e.g., Sommer et al., 2013; Floettoto et al., 2016; Sommer and Sullivan, 2017). The rental supply elasticity in these endogenous-landlord models is endogenous but tends to be substantially higher than our estimate. For example, the results reported by Floettoto et al. (2016) imply an elasticity of 38, which corresponds to a property tax incidence for renters of more than 90%.[12] In short, the rental supply is substantially more elastic under both approaches than indicated by the evidence on property tax incidence and the share of rental vouchers captured by landlords, which implies that shifts in demand for rental housing lead to counterfactually small changes in rents.

The one exception is Chambers et al. (2009), which is a mixture of these two approaches. It features a representative rental corporation with a finitely-elastic supply curve and individual households that supply rentals endogenously, resulting in an aggregate supply elasticity of about 1.6. However, this study does not identify the corporate supply elasticity in their model using any empirical evidence (they simply set it arbitrarily); providing a means of identifying this crucial parameter is one of our methodological contributions. Moreover, despite the fact that this study has a realistically low aggregate rental supply elasticity, it predicts that removing the MID would be welfare-improving because it does not account for our second key factor: many renters spend

[10] Suppose that rental demand is $D = N \times p_r^{\epsilon_d}$ and rental supply is $S = p_r^{\epsilon_s}$, where N is population, p_r is rent, and ϵ_d and ϵ_s are the price elasticities of demand and supply, respectively. Then the equilibrium rent is $p_r^{\star} = N^{1/(\epsilon_s - \epsilon_d)}$. Using Albouy et al. (2016)'s estimate of -0.65 for the elasticity of housing demand, we can back out ϵ_s using the changes in N and p_r reported in Trojanek and Gluszaks (2022), yielding $\epsilon_s = 0.4$ for Warsaw and $\epsilon_s = 0.7$ for Kraków.

[11] Greenwald and Guren (2021)'s definition of the tenure supply curve ("the menu of price-rent ratios at which landlords are willing to supply differing amounts of rented housing. . . at a given amount of aggregate housing supply") is not precisely the same as the rental supply elasticity in our model. The key difference is that the former holds fixed the aggregate housing stock, while the latter does not. However, the aggregate housing stock is likely to be almost perfectly fixed in the short run, so the two concepts are essentially equivalent in this context.

[12] We study a version of the endogenous-landlord model in Section 5.3. We confirm that the aggregate rental supply in this model is highly elastic and that the effect of homeownership policies in this model are similar to the effects in a model with an infinitely-elastic rental management company.

large shares of their income on rent.[13]

2.2. *Prevalence of cost-burdened renters*

The second factor is that many renters spend large shares of their income on housing. For these cost-burdened households, even small changes in rents have large welfare consequences, and the more of these households there are, the more important these consequences are for aggregate welfare.

2.2.1. *Identification*

In our model, the number of cost-burdened renters is governed by the minimum size of a rental dwelling. The identification here is straightforward: low-income households are constrained by the minimum rental size, and when this size increases, they are forced to spend a larger fraction of their income on rent. To match the share of cost-burdened renters in the data, our model requires a minimum rental size that is about 40% of the average owner-occupied house size. In Section 4.3, we show that our model matches the entire rent-to-income distribution closely, especially on the right tail, which is most important for capturing the welfare consequences of changes in rents.

2.2.2. *Empirical evidence*

Figure 2 shows the distribution of housing costs relative to income for renters in the 2019 SCF. We use the HUD's definition of a severely cost-burdened household as one that spends at least 50% of its gross income on housing (Larrimore and Schuetz, 2017).[14] In the SCF data, 15.1% of U.S. renters are severely cost-burdened. Of course, some renters spend substantially larger shares of their income on housing; for example, almost 4% of renters spend more than 75%.

2.2.3. *Previous quantitative studies*

There is little consistency in how previous quantitative studies have disciplined the minimum rental size. Some papers, like Sommer et al. (2013), Sommer and Sullivan (2017), and Karlman et al. (2021), do not report values or calibration targets for this parameter. Others like Chambers et al. (2009) and Floettoto et al. (2016) assume there is no lower bound on the size of rental dwellings at all. This explains why Chambers et al. (2009) find that repealing the MID would improve welfare, even though their rental supply elasticity is close to ours. The closest calibration

[13] Chambers et al. (2009) impose no restriction on the minimum size of a rental dwelling and this implies that all renters spend the same amount on housing relative to goods consumption. When the MID is removed in their model, rents rise by 4%, which would have massively negative welfare consequences for low-income renters if they matched the share of cost-burdened renters as we do. In our model, rents rise by only 2.35% and this is enough to generate welfare losses.

[14] The HUD defines a household that spends at least 30% of its income on housing as cost-burdened, and a household that spends at least 50% as severely cost-burdened. The former definition is more widely used to assess housing affordability in the United States (Herbert et al., 2018). We use the latter definition as our calibration target because it allows us to do a significantly better job of matching the entire right tail of the rent-to-income distribution. Calibrating to the 30% threshold instead leads our model to substantially understate the number of households who spend larger shares of their income on rent, whereas targeting the 50% threshold allows us to also match closely the number of renters who spend 60%, 75%, 80%, etc. of their income on rent, which are important for welfare outcomes. For brevity, we use the terms "cost-burdened" and "severely cost-burdened" interchangeably.

to ours on this dimension is Gervais (2002), who chooses the minimum rental size so that households in the bottom quintile of the income distribution devote 50% of their spending to housing on average. This study still finds that repealing the MID would be optimal because it assumes an infinitely elastic rental supply. As we show in our quantitative analysis below, repealing the MID lowers welfare only when one takes both of the key factors discussed in this Section into account.

2.3. *Other factors*

The goal of this study is to highlight the importance of the two factors described above in determining how rents respond to housing policies like the mortgage interest deduction and how these responses affect welfare. Before moving on to our analysis, it is important to point out that there are several other factors that could also play a role.

2.3.1. *Elasticity of aggregate housing supply*

In addition to the rental supply elasticity, there is another elasticity that determines how homeownership subsidies affect prices in equilibrium: the elasticity of the aggregate housing supply, which governs the sensitivity of house prices to demand for housing services. When demand for owner-occupied housing shifts inward, as it does when the MID is eliminated, a higher housing supply elasticity implies that house prices fall less and homeownership falls more in equilibrium. If the rental supply is perfectly elastic, rents move one-for-one with house prices, so a smaller drop in house prices implies a smaller drop in rents. However, if the rental supply elasticity is low, rents depend on demand for rental housing as well as house prices, so the smaller drop in house prices and the larger drop in homeownership cause a larger increase in rents. Thus, a higher housing supply elasticity makes the rental supply elasticity play an even larger role in determining the welfare consequences of housing policy. In our calibration, we use a conservatively low estimate of the housing supply elasticity from Sommer and Sullivan (2017). As we show in Section 5.3, using a higher elasticity like that estimated by Saiz (2010) only makes our point stronger.

2.3.2. *Labor supply*

Like many other studies in the quantitative housing literature, we assume that households receive exogenous endowments of labor income. One could argue, though, that renters, especially those that are rent-burdened, might respond to an increase in rents by working more. In Section 5.3, we show that this channel reduces, but does not eliminate, the welfare losses from eliminating the MID or taxing imputed rents.

2.3.3. *Household (de)formation*

Another way that cost-burdened renters, especially younger ones, might respond to rent increases is by moving back home with their parents, as in Kaplan (2012). We allow for a "moving back home" channel in Section 5.3 and show that even with this channel at play, repealing the MID or taxing imputed rents would result in welfare losses.

3. Model

The model economy features overlapping generations of finitely-lived households, a construction company, a rental company, and a government. Households supply labor inelastically and choose consumption of goods and housing services; whether to rent, buy, or sell a home; how much to save; and how much mortgage debt to take on. The construction company builds new housing and the rental company purchases existing housing units to rent out. The government levies taxes on income and property and provides social security benefits to retirees. The key ingredients that help us match the two key facts described above are the convexity of the rental company's management cost, which governs the slope of the rental supply curve, and the minimum size of a rental dwelling, which determines the number of renters that spend the majority of their income on housing.

In many respects, our model is similar to others in the quantitative housing literature, particularly those listed in Table 1. As in Karlman et al. (2021), we include a detailed demographic structure that realistically captures the full household life cycle. Like Chambers et al. (2009), Sommer and Sullivan (2017), and Karlman et al. (2021), we include a progressive income tax system, which is important for capturing the fact that the benefits of the MID accrue primarily to high-income households. Similar to Sommer and Sullivan (2017), housing investment is endogenous, which means that both the price and quantity of housing respond to shifts in demand. Following Gervais (2002), Nakajima (2020), and Karlman et al. (2021), rental housing is supplied by a competitive rental company, but we allow the rental management cost to be convex as in Chambers et al. (2009).[15] As in Gervais (2002), Sommer and Sullivan (2017), and Karlman et al. (2021), there is a tenure-specific lower bound on house size. Finally, like Chambers et al. (2009) and Karlman et al. (2021), we model mortgages as long-term contracts with borrowing constraints that apply at origination. These similarities are intentional and consistent with our goal, which is to study how incorporating the two key factors discussed in the previous section into an otherwise-standard quantitative housing model alters the welfare consequences of homeownership subsidies like the MID.

3.1. Demographics and preferences

There are overlapping generations of households that face mortality risk. Age is indexed by j. Households are born at age $j = 1$, retire at age J_R, and live for a maximum of J years. The probability of surviving from age j to age $j + 1$ is ϕ_j, with $\phi_J = 0$. There is a measure one of newborn households each period, which implies that the measure of age-j households is $\Pi_{k=1}^{j-1}\phi_k$.

Living households have preferences over consumption of goods, c, and housing services, h, given by the flow utility function

$$u_j(c,h) = \xi_j^{\sigma}\frac{\left(c^{1-\gamma}h^{\gamma}\right)^{1-\sigma}}{1-\sigma}. \tag{1}$$

The parameter γ is the weight on housing services, σ governs risk aversion and the intertemporal elasticity of consumption, and ξ_j is an equivalence-scale parameter that captures variation in household size over the life cycle.

[15]We show in the appendix that the approach taken by Floettoto et al. (2016) and Sommer and Sullivan (2017) in which rental housing is supplied by individual households who choose endogenously to be landlords is similar to a model with an infinitely price-elastic rental company.

Decedents have warm-glow preferences over bequests given by $w_B(q) = \mu \frac{q^{1-\sigma}}{1-\sigma}$, where q denotes end-of-life net worth, which we define below, and the parameter μ governs the strength of the bequest motive.

3.2. Endowments

Working-age households ($j < J_R$) receive an idiosyncratic endowment of labor income,

$$y_j(x, z) = \zeta_j x z, \tag{2}$$

where ζ_j is a life-cycle profile common to all households; $x \in \mathcal{X}$ is an idiosyncratic fixed effect that is constant throughout a household's life and drawn from a distribution $G(x)$ at birth; and $z \in \mathcal{Z}$ is an idiosyncratic shock that follows a Markov process $F(z, z')$ with ergodic distribution $\bar{F}(z)$.

Retired households ($j \geq J_R$) receive social security benefits given by

$$y_R(x, z) = \kappa(x, z) \int_{\mathcal{X}\times\mathcal{Z}} y_j(x, z) \, \mathrm{d}G(x)\mathrm{d}\bar{F}(z). \tag{3}$$

The function $\kappa(x, z)$ represents the fraction of the average labor income that a retiree with fixed effect x and shock z receives. This allows us to capture, in a reduced-form way, the correlation between lifetime labor income and social security benefits.

In addition to the income endowments described above, newborn households have a chance of receiving endowments of financial wealth as in Kaplan and Violante (2014). Specifically, a fraction $\theta(x)$ of newborns with fixed effect x are born with endowment $a_1(x)$. This allows us to capture the fact that higher-income young households are wealthier on average and are more likely to have positive net worth.

Following Karlman et al. (2021), surviving households also receive endowments of financial wealth in order to ensure that the aggregate amount of bequests left by decedents equals the aggregate amount of financial endowments across the entire population of living households. Specifically, we assume that surviving households of age $j > 1$ receive financial endowments of $\vartheta(x, z)$, which is a parsimonious way to capture the fact that bequests received later in life are also unequally distributed and correlated with income.

3.3. Housing and mortgages

Housing services are obtained by renting or owning a home. We denote a household's tenure by $o \in \{0, 1\}$, where 0 indicates a renter and 1 indicates a homeowner. Each unit of housing provides the same amount of housing services regardless of tenure, but there is a tenure-specific lower bound on house size: rental units cannot be smaller than $\underline{h}_r$, while owner-occupied dwellings cannot be smaller than $\underline{h}_o$. The per-unit price of housing is p, and the rental price is p_r. Buying and selling a house require one-time proportional transaction costs, τ_b, and τ_s, respectively. Rental and owner-occupied housing are both taxed at a rate τ_p and depreciate in value at a rate δ.

Households can save at an exogenous interest rate of r.[16] We denote a household's savings as a. Unsecured borrowing is not allowed, but homeowners have access to mortgage debt, m.

[16]The assumption of a small open economy is prevalent in the quantitative housing literature. See, for example,

The interest rate on mortgages is $r_m = r + \Delta_m$, where Δ_m is the mortgage premium. Mortgages are modeled as long-term debt with borrowing restrictions, prepayment penalties, and origination costs using a similar approach as Karlman et al. (2021).

Originating a new mortgage incurs a fixed cost ω_1. Two restrictions apply at the time of origination. The first is a loan-to-value (LTV) constraint, which limits mortgages to a fraction λ_1 of the house's purchase price ph:

$$m \leq \lambda_1 ph. \tag{4}$$

The second is a payment-to-income (PTI) constraint, which limits carrying costs to a fraction λ_2 of gross income:

$$\tau_p ph + (r_m + \nu_1)m \leq \lambda_2[y_j(x,z) + ra], \tag{5}$$

where ν_1 is the minimum allowed principal payment as a fraction of the mortgage balance. Retirees cannot originate new mortgages but can carry existing debt into retirement.

Homeowners with existing mortgages must either pay at least a fraction ν_1 of their mortgage debt, or originate a new mortgage to repay the old one in full (i.e., refinance). Paying more than a fraction ν_2 of an existing mortgage triggers a prepayment penalty, given by

$$\tau_{pp}(m, m') = \omega_2 \max\{(1 - \nu_2)m - m', 0\}, \tag{6}$$

where m' is the mortgage balance at the end of the period. Refinancing incurs both the origination cost and the prepayment penalty.

3.4. Income taxes

Working-age households pay taxes on their labor income after taking a personal exemption and either a standard or itemized deduction. Taxable labor income is given by

$$\tilde{y}_j(x, z, o, h, m) = \max\{y_j(x,z) - \tau_e - \max[\tau_d, o(\tau_m r_m m + \tau_p ph)], 0\}, \tag{7}$$

where τ_e is the personal exemption, τ_d is the standard deduction, and τ_m is the fraction of mortgage interest payments that can be deducted if a household chooses to itemize. Labor income taxes are progressive following Heathcote et al. (2017). A household's labor income tax liability is

$$\tau_j(x, z, o, h, m) = \tilde{y}_j(x, z, o, h, m) - \tau_\ell \tilde{y}_j(x, z, o, h, m)^\psi, \tag{8}$$

where τ_ℓ controls the average level of taxation in the economy and ψ controls the degree of progressivity. All households pay a proportional tax τ_k on capital income.

Sommer et al. (2013), Arslan et al. (2015), Floettoto et al. (2016), Sommer and Sullivan (2017), Kaplan et al. (2019), and Karlman et al. (2021). Under the hood, so to speak, we allow households to save in bonds and also purchase stock in the rental and construction companies, but a no-arbitrage condition requires households to be indifferent between these two options, i.e., the rate of return on stock must be the same as the exogenous world interest rate. Because we do not require the asset market to clear, we do not need to explicitly keep track of the dividends associated with these stock holdings. An alternative interpretation is that the rental and construction companies are owned by foreigners, as in Floettoto et al. (2016).

3.5. Dynamic program

A household's state variables are its idiosyncratic labor income, (x, z), its financial wealth, a, its tenure, o, its house size, h, and its mortgage debt, m. Given these state variables, which we collectively denote by s, it chooses saving, a'; housing tenure, o'; consumption of goods and housing services, c and h'; whether to originate a new mortgage, n; and mortgage debt at the end of the period, m'. The dynamic program that represents this optimization problem for a household of age $j \geq 2$ is

$$V_j(s) = \max_{c,a',o',h',n,m'} \left\{ u_j(c, h') + \beta\phi_j \int_{\mathcal{Z}} V_{j+1}(s')\, \mathrm{d}F(z, z') + (1 - \phi_j) w_B(q') \right\} \tag{9}$$

subject to

$$\begin{aligned} c + a' + r_m m + (1 - o')p_r h' + o\left[\delta + \tau_p + \mathbb{1}_{\{o'=0 \vee h' \neq h\}}\tau_s\right] ph + o'(1 + \mathbb{1}_{\{o=0 \vee h' \neq h\}}\tau_b)ph' \\ = y_j(x, z) - \tau_j(x, z, o, h, m) + [1 + r(1 - \tau_k)]a + oph + \vartheta(x, z) + \\ m' - m - n[\omega_1 + \tau_{pp}(m, 0)] - (1 - n)\tau_{pp}(m, m') \end{aligned} \tag{10}$$

$$a' \geq 0 \tag{11}$$

$$h' \geq o'\underline{h}_o + (1 - o')\underline{h}_r \tag{12}$$

$$n \in \{0, o'\mathbb{1}_{\{j<j_R\}}\} \tag{13}$$

$$nm' \leq \lambda_1 ph' \tag{14}$$

$$n[\tau_p ph' + \nu_1 m'] \leq \lambda_2(y_j(x, z) + ra) \tag{15}$$

$$(1 - n)m' \leq (1 - \nu_1)m \tag{16}$$

$$q' = a' + o'\left[ph'(1 - \delta - \tau_p) - m'\right] \tag{17}$$

The first constraint (10) is the budget constraint. The left-hand side includes spending on consumption, saving, mortgage interest, rent (if $o' = 0$), property taxes and depreciation (if $o = 1$), and the costs of buying and/or selling houses, which apply only when tenure and/or house size change. The right-hand side includes after-tax income, financial wealth and housing wealth, funds raised by taking on a mortgage, origination costs for new mortgages (if $n = 1$), and prepayment costs for early mortgage balance payments. The budget constraint of a newborn is similar, except that $\vartheta(x, z)$ is replaced with either $a_1(x)$ or zero, depending on the individual's realization of the initial endowment. The second constraint (11) states that unsecured borrowing is not allowed. The third constraint (12) states that renters cannot live in houses smaller than $\underline{h}_r$ and owners cannot live in houses smaller than $\underline{h}_o$. The fourth constraint (13) states that a household can only originate a new mortgage if it is below retirement age and is a homeowner at the end of the period. The fifth and sixth constraints (14)–(15) are the LTV and PTI constraints, which apply only when the household originates a new mortgage. The seventh constraint (16) states that households with existing mortgages must repay at least a fraction ν_1 of the principal. The last constraint states that a household's net worth is equal to the sum of its financial wealth and its housing equity. We denote the policy functions for consumption, savings, tenure, housing, mortgage origination, mortgage debt, and bequests by $c_j(s)$, $a'_j(s)$, $o'_j(s)$, $h'_j(s)$, $n_j(s)$, $m'_j(s)$, and $q'_j(s)$, respectively.

3.6. Rental company

We use the corporate rental market structure from Chambers et al. (2009). The rental company begins each period with a stock of rental housing, S, on which it pays property taxes and depreciation costs. It chooses how much additional rental housing to purchase, $S' - S$, earns rental income $p_r S'$, and incurs management costs $C_r(S') = \frac{\theta_1}{\theta_2} S'^{\theta_2}$. The rental company's dynamic program is

$$W_r(S) = \max_{S'} \left\{ p_r S' - C_r(S') - p(S' - S) - p(\delta_h + \tau_p)S + \frac{1}{1+r} W_r(S') \right\}.$$

The solution to this problem is given by

$$p_r = \theta_1 (S')^{\theta_2 - 1} + \left\{ \frac{r + \delta_h + \tau_p}{1 + r} \right\} p. \tag{18}$$

The parameter θ_2 governs the elasticity of the rental housing supply to the rental price. When $\theta_2 = 1$, the rental supply is perfectly elastic as in Gervais (2002) and Kaplan et al. (2019), which means that the price-rent ratio is independent of the quantity of rental housing supplied. When $\theta_2 > 1$, the rental supply curve slopes upward, which means that the rental price rises in equilibrium when demand for rental housing shifts outward. An imperfectly elastic rental supply captures real span-of-control frictions, financial frictions, and other factors that make managing rental housing more difficult or more costly as the scale of a landlord's operation grows. In our calibration, we choose θ_2 so that the model matches empirical estimates of how the property tax incidence is split between landlords and renters.

3.7. Construction company

As in Sommer and Sullivan (2017) and Rotberg (2022), a construction company chooses how much new housing to build, X, subject to a convex cost $C_h(X) = \frac{\epsilon_1}{\epsilon_2} X^{\epsilon_2}$. The construction company's problem is

$$\Pi_x = \max_X \{pX - C_h(X)\}, \tag{19}$$

which yields the following relationship between housing investment and the price of housing:

$$p = \epsilon_1 X^{\epsilon_2 - 1}. \tag{20}$$

This expression shows that the price elasticity of the supply of new housing construction is governed by ϵ_2. The aggregate stock of housing follows the law of motion,

$$H' = (1 - \delta)H + X. \tag{21}$$

In a stationary equilibrium, the aggregate housing stock is constant, i.e., $H' = H = \frac{X}{\delta}$.

3.8. Aggregation and equilibrium

There are two housing market clearing conditions. The first states that total demand for housing from both renters and owners must equal the total supply:

$$\sum_{j=1}^{J} \int_{\mathcal{S}} h_j'(s) \, \mathrm{d}\Psi_j(s) = H', \tag{22}$$

where Ψ_j is the distribution of age-j households over the state space $\mathcal{S}$. The second market clearing condition states that demand for rental housing must equal the quantity supplied by the rental company:

$$\sum_{j=1}^{J} \int_{\mathcal{S}} (1 - o_j'(s)) h_j'(s) \, \mathrm{d}\Psi_j(s) = S'. \tag{23}$$

The government's budget also must balance:

$$G + \sum_{j=J_R}^{J} \int_{\mathcal{S}} y_R(x, z) \mathrm{d}\Psi_j(s) = \sum_{j=1}^{J} \int_{\mathcal{S}} \left[\tau_j(s) + \tau_k ra\right] \mathrm{d}\Psi_j(s) + \tau_p pH. \tag{24}$$

The left-hand side of the government's budget constraint contains expenditures on public goods and social security benefits. The right-hand side includes revenues from income and property taxes. When we calibrate the model to the current U.S. tax code, we set the consumption level of public goods, G, to ensure that this constraint holds as in Díaz and Luengo-Prado (2008). Then, in our counterfactual experiments, we hold G fixed.

Additionally, total bequests left by decedents must equal total wealth endowments:

$$\sum_{j=1}^{J} \int_{\mathcal{S}} (1 - \phi_j) q_j'(s) \, \mathrm{d}\Psi_j(s) = \int_{\mathcal{X}} \theta(x) a_1(x) \, \mathrm{d}G(x) + \sum_{j=2}^{J} \int_{\mathcal{S}} \vartheta(x, z) \, \mathrm{d}\Psi_j(s). \tag{25}$$

The first term on the right-hand side represents newborns' initial wealth endowments, while the second represents surviving households' endowments. As in Karlman et al. (2021), we choose ϑ residually so that this condition is always satisfied in our experiments. Thus, ϑ changes (albeit only slightly) in our counterfactual experiments in proportion to the changes in aggregate bequests.

Finally, the distribution over the household state space evolves as follows. Households are born as renters with zero housing wealth, so the distribution of newborn households, $\Psi_1(s)$, is given by

$$\Psi_1(S) = \int_{\mathcal{X}\times\mathcal{Z}} \left[\theta(x) \mathbb{1}_{\{(x,z,a_1(x),0,0,0)\in S\}} + (1 - \theta(x)) \mathbb{1}_{\{(x,z,0,0,0,0)\in S\}}\right] \, \mathrm{d}G(x) \mathrm{d}\bar{F}(z), \tag{26}$$

where S is a typical subset of the state space and $\bar{F}$ is the unconditional distribution of labor productivity shocks associated with the process $F(z, z')$. The distributions of older households evolve according to the law of motion

$$\Psi_{j+1}(S) = \phi_j \int_S \left[\int_Z \mathbb{1}_{\{(x,z',a'_j(s),o'_j(z),h'_j(s),m'_j(s))\in S\}} \, \mathrm{d}F(z,z') \right] \mathrm{d}\Psi_j(s), \;\; j = 1, \ldots, J-1. \tag{27}$$

A stationary equilibrium is a collection of aggregate prices and quantities, value and policy functions, and distributions,

$$\left\langle p, p_r, H', S', \left\{ V_j(s), c_j(s), a'_j(s), o'_j(s), h'_j(s), n_j(s), m'_j(s), q'_j(s), \Psi_j(s) \right\}_{j=1}^{J} \right\rangle, \tag{28}$$

that solve the household's dynamic problem (9), satisfy the rental company's first-order condition (18), satisfy the construction company's first order condition (20), clear the markets for housing and rentals (22)–(23), satisfy the government's budget constraint (24) and the bequest constraint (25), and satisfy the distributional laws of motion (26)–(27).

4. Calibration

We calibrate our model so that its stationary equilibrium matches salient features of the U.S. economy under the current tax code. We first assign standard values to common parameters and use estimates from other studies for parameters that have clear empirical counterparts. We then jointly calibrate the remaining parameters so that the model matches a set of important facts about the housing market. Table 3 lists all the calibrated parameters alongside their source or target moment.

4.1. Assigned parameters

There are several groups of externally assigned parameters. They are listed in panels (a)–(e) of Table 3.

4.1.1. Demographics and preferences

A model period corresponds to one year. Households start their lives at age 26, retire at age 66, and live up to age 85, implying that lifespan $J = 60$ and retirement age $J_R = 41$. We set the utility's relative risk aversion parameter, σ to 2. The survival probabilities are taken from the U.S. Life Tables (Arias, 2014). The equivalence scales are set using data from the 2017 American Housing Survey (AHS). We first compute the average household size by age of the head of household, and then take the square root, as is common in the literature. The discount factor, β, the share of housing services in utility, γ, and the strength of the bequest motive, μ, are determined in the second stage of our calibration procedure.

4.1.2. *Labor income process*

We use the labor income process from Guvenen et al. (2023). The standard deviation of the fixed effect is 0.128.[17] Labor productivity shocks follow an AR(1) process in logs,

$$\log z' = \rho_z \log z + \epsilon_z, \quad \epsilon_z \sim N(0, \sigma_z), \tag{29}$$

with $\rho_z = 0.9$ and $\sigma_z = 0.20$. The deterministic life-cycle component of labor market productivity, ζ_j, is a quadratic polynomial that rises by 50% to a peak at age 51.

4.1.3. *Wealth endowments*

We take a similar approach to Karlman et al. (2021) to calibrating the wealth endowment parameters. We assign $\theta(x)$ and $a_1(x)$, which determine newborn households' endowments, using data from the 2019 Survey of Consumer Finances (SCF). We sort households in the SCF aged 23–27 into deciles by income, and compute two statistics for each decile: the fraction of households with net worth greater than \$1,000; and the median net worth conditional on having at least \$1,000, measured as a fraction of the median net worth for all working-age households. We then set $\theta(x)$ and $a_1(x)$ to reproduce these moments. We assume that surviving households' endowments are proportional to the idiosyncratic component of their labor income: $\vartheta(x, z) := \vartheta xz$. As discussed above, the scale factor ϑ, which governs surviving households' wealth endowments, is chosen residually so that equation (25) is always satisfied.

4.1.4. *Taxes*

We set the interest rate to 3% as in Kaplan et al. (2019) and the capital income tax rate to 15% as in Karlman et al. (2021). We set the personal exemption, τ_e, to 43% of the standard deduction (the equivalent of \$4,050 as in the U.S. tax code). We set the labor income tax progressivity parameter, ψ, to 0.85 based on Heathcote et al. (2017). The average level of taxation, τ_ℓ, and the standard deduction, τ_d, are set in the second stage of our calibration. We also follow Guvenen et al. (2023) in setting $\kappa(x, z)$, which determines the extent to which social security benefits depend on productivity shocks.

4.1.5. *Housing market*

The property tax rate, τ_p, is set to 1% as in Sommer et al. (2013) and the housing depreciation rate to 0.6% as estimated by Rosenthal (2014). Buying costs, τ_b, are set to 2% of the purchase price and selling costs, τ_s, are set to 6% of the sale price based on estimates by Gruber and Martin (2003). Lastly, we choose $\epsilon_2 = 1.9$ so that the price elasticity of the housing supply is 0.9 as estimated by Sommer and Sullivan (2017). The level of the construction company's cost function, ϵ_1, is a free parameter that is backed out from the market clearing condition (22).

[17] Guvenen et al. (2023) assume that fixed effects are transmitted from parents to newborns with an intergenerational persistence of 0.5 and a standard deviation of intergenerational innovations of 0.31. This implies an unconditional standard deviation of $\sqrt{0.31^2/(1-0.5^2)} = 0.128$.

4.1.6. Mortgages

The mortgage parameters are set based on standard U.S. banking practices, as in Kaplan et al. (2019) and Karlman et al. (2021). The interest rate premium on mortgage debt, Δ_m, is set at 1%, which is consistent with the historical difference between interest rates on 30-year government bonds and mortgage interest rates. The maximum LTV ratio, λ_1, is set to 0.95 so that the minimum down payment is 5%. The maximum PTI ratio, λ_2, is set to 0.39, which is a common threshold set by lenders in the United States. The minimum payment is given by $\nu_1 = r_m(1+r_m)^{30}/[(1+r_m)^{30}-1]$, which represents the payment on an annuity mortgage with a 30-year term. The prepayment penalty threshold, ν_2, is set to 17.8%. The origination cost, ω_1, is set to the model equivalent of $2,000, which captures application, attorney, appraisal, and inspection fees. The prepayment penalty, ω_2, is set to the model equivalent of 3 months' interest.

4.2. Internally calibrated parameters

After assigning the parameter values listed above, there are nine parameters that still must be calibrated: the discount factor, β; the utility weight on housing services, γ; the utility weight on bequests, μ; the average level of labor income taxation, τ_ℓ; the standard deduction, τ_d; the parameters of the rental company's management cost function, θ_1 and θ_2; the minimum size of a rental, $\underline{h_r}$, and the minimum size of an owner-occupied house, $\underline{h_o}$. We jointly calibrate these parameters to match nine statistics, which are computed using data from the 2019 Survey of Consumer Finances (SCF) unless stated otherwise:

- the overall homeownership rate, which is 65.9%;
- the homeownership rate of households aged 65 or greater, which is 80.4%;
- the ratio of aggregate mortgage debt to aggregate housing wealth, which is 0.35;
- the average ratio of rent to income for renters, which is 0.31;
- the aggregate mortgage interest deduction as a percentage of GDP, which is 0.41% according to the Joint Committee on Taxation (JCT);
- the average labor income tax rate, which is 22.4% as estimated by McDaniel (2007);
- the rent to housing price ratio, which is 0.08 as reported by Garner and Verbrugee (2009);
- the property tax incidence of renters, which we set at 50% as discussed in Section 2.1;
- and the fraction of renters who spend at least 50% of their income on rent, which is 15.1%.

The results of this stage of the calibration procedure are listed in panel (f) of Table 3. The internally-calibrated parameters are not individually identified, but each moment listed above plays a key role in identifying one of these parameters. The approximate mapping between moments and parameters is as follows. The mortgage debt/house value ratio pins down the discount factor, β. The lower β, the more debt homeowners are willing to take on. The average rent to income ratio determines the utility weight on housing, γ. The higher γ, the more of their income renters spend on housing. The homeownership of older households controls the utility weight on bequests, μ. The higher μ, the more net worth households want to have when they die, which reduces older households' incentives to consume housing equity. The average labor income tax rate identifies the labor income tax level parameter, τ_ℓ. The lower τ_ℓ, the higher the average tax rate. The MID/GDP ratio governs the standard deduction, τ_d. When τ_d rises, fewer households choose to itemize mortgage interest payments, and the aggregate tax revenue lost due to the MID falls. The rent/price ratio pins down the parameter that governs the level of the rental management cost, θ_1. The higher θ_1, the higher the marginal cost of supplying rental housing, and the higher the rent-price ratio must be in equilibrium. The homeownership rate determines the minimum owned house size, $\underline{h_o}$. The higher $\underline{h_o}$, the fewer households will choose to own. Most importantly for our study, the share of property taxes borne by renters identifies θ_2, and the number of renters spending a majority of their income on housing controls $\underline{h_r}$. The identification of these parameters is discussed in detail in Section 2 above.

4.3. Validation

Table 4 and Figures 2–3 show that the model performs well in reproducing other salient facts that we did not target in our calibration. First, it matches closely the fraction of homeowners with mortgage debt, the distribution of loan-to-value ratios, and the fraction of households who take the MID instead of the standard income tax deduction. This indicates that the model is well-equipped to study the effects of eliminating the MID.

Second, the model captures the fact that renters are concentrated in the bottom of the income distribution, which means that it is equipped to study how changes in rents affect low-income households. Further, although we have targeted only the fraction of renters who spend at least 50% of their income on housing, the model matches the overall CDF quite closely. Generally, the model slightly under-predicts the CDF at very high rent-to-income ratios (e.g. the fraction of renters who spend at least 75% of their income on rent), which indicates that the model provides a conservative assessment of the welfare consequences of changes in rents for low-income households.

Third, the model reproduces the life-cycle dynamics of homeownership, mortgage debt, net worth, and the prevalence of cost-burdened renters. In the model, as in the data, homeownership and net worth rise with age, mortgage debt (measured relative to housing wealth) falls, and the fraction of cost-burdened renters follows a hump-shaped trajectory with a peak in the late 50s. Quantitatively, homeownership among young households is lower in the model than in the data while homeownership among middle-aged households is higher, older households have less mortgage debt, and the fraction of middle-aged renters who are cost-burdened is higher.[18]

Finally, the rental supply elasticity we have identified using evidence on renters' property tax incidence is also consistent with the evidence on the share of rental vouchers captured by landlords. To compute this statistic in our model, we conduct a counterfactual in which renters in the bottom 40% of the income distribution are provided with a lump-sum transfer equal to 5% of the average rent or their housing expenses, whichever is lower.[19] We measure the share of vouchers that are captured by landlords as the change in aggregate rents divided by the aggregate voucher amount.

[18]The last difference is largely a function of the first. Since the model has too few middle-aged renters, the few middle-aged households who do rent in the model have low incomes and are likely to be cost-burdened.

[19]See the description of the model with rental vouchers in Appendix B for more details. The results are similar when we use larger voucher size. We chose 5% of the average rent, which is fairly small, in order to get an accurate measure of the slope of the supply curve near the model's initial equilibrium.

We obtain a value of 55%, which is precisely the mean of the empirical estimates listed in panel (b) of Table 2. This further confirms that our calibrated rental supply elasticity is empirically plausible and appropriate for analyzing the long-run effects of housing policy reforms.

4.4. Alternative calibrations

In addition to the benchmark calibration described above, we construct two alternative calibrations that represent standard approaches in the quantitative housing literature. Each alternative ignores one of the key facts described in Section 2.

4.4.1. Infinite rental supply elasticity

In the first alternative calibration, we set $\theta_2 = 1$ so that the rental housing supply is infinitely elastic with respect to rents. This is the setup employed by Gervais (2002), Kaplan et al. (2019), Nakajima (2020), and Karlman et al. (2021). As we show in the appendix, it is also quantitatively similar to the models of Floettoto et al. (2016) and Sommer and Sullivan (2017) in which rental housing is supplied by individual households who choose to be landlords; for example, the results reported by Floettoto et al. (2016) imply an elasticity of 38, which is 21 times larger than the elasticity in our benchmark. Otherwise, this calibration is identical to the benchmark in all respects, except that we recalibrate θ_1 to keep the rent-price ratio at the target value of 0.08.

4.4.2. No minimum rental size

In the second alternative calibration, we eliminate the lower bound on rental size by setting $\underline{h_r} = 0$. This is the setup in Chambers et al. (2009) and Nakajima (2020). Many other studies like Floettoto et al. (2016), Sommer and Sullivan (2017), and Karlman et al. (2021) have lower bounds on rental size but do not target any moment of the rent-to-income distribution or compare this distribution in their models to the data. Eliminating this constraint requires us to recalibrate all the other parameters described in Section 4.2. In this calibration, only 4.2% of renters spend more than 50% of their income on housing, and the overall rent-to-income distribution is much further from the data as shown by Figure 2a.

On its own, the fact that much fewer low-income households are cost-burdened in this calibration is crucial for welfare outcomes, because it implies that they are less affected by changes in rents. Moreover, it also implies that rental demand is more elastic; renters can downsize more easily in response to rent increases, so aggregate rental demand is more price-sensitive. And because this calibration has a shallower rental demand curve, it requires a higher rental supply elasticity to match the 50% property-tax incidence target. The rental supply elasticity in this calibration is about six, more than four times greater than in the benchmark. This means that rents respond less in equilibrium to changes in demand, which also plays an important role in welfare outcomes.

5. Quantitative analysis

We use our model to conduct two commonly studied experiments to illustrate the importance of the key facts discussed in Section 2 for the welfare consequences of housing policy. In the first experiment, we eliminate the MID. In the second, we tax homeowners' imputed rents at the same rate as other capital income. As in the other quantitative studies of homeownership subsidies listed in Table 1, we restore fiscal balance in both experiments by adjusting the parameter τ_ℓ, which governs the average labor income tax rate.[20] The results of these experiments are shown in Table 5.

Our aggregate welfare criterion is the ex-ante expected utility of a newborn household measured in consumption-equivalent terms as in Conesa et al. (2009) and Guvenen et al. (2023). This measure is given by the formula

$$W = \left[\frac{\int_S V_1^\dagger(s) d\Psi_1(s) - \sum_{j=1}^J (1-\Phi_j) \int_S w_B(q_j'^*(s)) d\Psi_j(s)}{\int_S V_1^*(s) d\Psi_1(s) - \sum_{j=1}^J (1-\Phi_j) \int_S w_B(q_j'^*(s)) d\Psi_j(s)} \right]^{\frac{1}{(1-\gamma)(1-\sigma)}} - 1, \tag{30}$$

where stars denote objects in the benchmark stationary equilibrium and daggers denote objects in the stationary equilibria in our policy experiments. We also compute the approval rate for each policy change as the fraction of newborns whose welfare rises,

$$A = \int_S [V_1^\dagger(s) > V_1^*(s)] \, d\Psi_1(s). \tag{31}$$

The distribution of newborns is policy-invariant because newborns are exogenously endowed with net wealth as described in Section 3.2, i.e., $\Psi_1^* = \Psi_1^\dagger = \Psi_1$. To dig deeper into the distributional consequences, we also compute welfare for newborns in each income quintile. These distributional results are shown in Table 6.

5.1. *Repealing the MID*

In our first experiment, we study the effects of repealing the MID, i.e., setting $\tau_m = 0$. Numerous studies, such as Gervais (2002), Chambers et al. (2009), Floettoto et al. (2016), Sommer and Sullivan (2017), Nakajima (2020), and Karlman et al. (2021) have studied this reform, and without exception they have found welfare gains in the long run. Panel (a) of Table 5 shows the main results of this reform in our model, and panel (a) of Table 6 shows the distributional consequences.

5.1.1. *Benchmark calibration*

In the benchmark, repealing the MID would reduce aggregate welfare by 0.41% and hurt more than 40% of newborns. The economic intuition behind this result is as follows. Repealing the MID would reduce homeownership, which would shift demand for rentals outward. Because the supply of rentals is only moderately elastic, this would cause rents to rise by 2.35% despite the drop in house prices. This would hurt all renters, but low-income households, many of whom cannot downsize due to the lower bound on rental housing, would be hit especially hard: households in the bottom quintile of the income distribution would see welfare losses of 1.41%.

[20] In a previous version of the paper, we adjusted the standard deduction, τ_d. Especially in the case of the MID, we view this assumption as the most likely political outcome. In fact, this is precisely what happened in 2018, when the government increased the standard deduction and reduced the maximum amount of mortgage debt on which one could claim the MID. However, adjusting the labor income tax rate is the standard approach in the literature, and following a recommendation from the referee we decided it was more important for our quantitative exercises to be as comparable as possible to those of other studies. All of our results hold with either tax instrument.

5.1.2. *Infinite rental supply elasticity*

In the calibration with a perfectly elastic rental supply, aggregate welfare would rise by 0.93% and all newborns would experience a welfare gain. As in the benchmark, homeownership would fall, but in this calibration rents would decrease by 0.92%. This is because rents only respond to changes in house prices; they do not respond to shifts in demand. As equation (18) shows, when the rental supply is perfectly elastic the price-rent ratio is constant, and so the drop in house prices carries over almost one-for-one to rents. The drop in rents would benefit all renters, but especially those with low incomes for whom the rental size constraint binds. Consequently, households in the bottom quintile of the income distribution would gain the most from eliminating the MID in this calibration.

5.1.3. *No minimum rental size*

In the calibration without a minimum rental size, aggregate welfare would rise by 0.14% and almost 85% of newborns would gain. Although homeownership would fall more than in the benchmark calibration, rents would actually rise less because the rental supply is more elastic in this calibration, as discussed in Section 4.4. The smaller increase in rents, coupled with the fact that low-income renters can downsize, would lead to welfare gains, even for households in the bottom quintile of the income distribution.

5.1.4. *Effects on homeownership*

Before moving on, it is important to highlight that the two key factors discussed in Section 2 play important roles in determining the effect of the MID on homeownership as well as welfare. Other quantitative studies of MID repeal have reported a wide range of effects on homeownership, ranging from a 14.8p.p. drop in Floettoto et al. (2016) to a 5p.p. increase in Sommer and Sullivan (2017). By contrast, a recent empirical study by Gruber et al. (2021) finds that Denmark's 1987 MID reform had zero effect on homeownership, both in the aggregate and at the household level.[21] The effect on homeownership in our model is quite small and much closer to Gruber et al. (2021)'s finding compared to many previous quantitative studies.[22] Moreover, the effect is larger in our alternative calibrations than in our benchmark, which indicates that the rental supply elasticity and the prevalence of cost-burdened renters both help the model deliver empirically-plausible effects on homeownership.

The economic intuition behind the role of the rental supply elasticity in determining how homeownership responds to MID repeal is straightforward. *Ceteris paribus*, repeal makes owner-occupied housing more expensive, which shifts demand for owner-occupied housing inward and

[21] Gruber et al. (2021) find that aggregate homeownership remained constant for more than thirty years after the reform, and that homeownership among high-income households, for whom the reform reduced the rate at which mortgage interest could be deducted from income taxes, did not change relative to homeownership among lower- and middle-income households. They do find, however, that homeownership fell among younger households and rose among older households (see their Figure 2B). Our results are consistent with this finding, both qualitatively and quantitatively.

[22] One exception is Chambers et al. (2009), who find that repealing the MID would increase homeownership by 0.7p.p. However, this small effect is due to the fact that the price of housing is fixed in their model; if they had allowed prices to fall, homeownership would have increased more in equilibrium.

demand for rental housing outward. The first shift leads to a drop in house prices. The effect on rents depends on the rental supply elasticity, as described above. When this elasticity is high, the effect of house prices dominates and rents fall. When it is low, the shift in demand for rentals dominates and rents rise. In the latter case, the increase in rents causes a subsequent outward shift in demand for owner-occupied housing, increasing homeownership. The lower the rental supply elasticity, the greater this subsequent shift is, and the less homeownership falls.[23] The role of cost-burdened renters is secondary, in that it ultimately stems from the same mechanism. As described in Section 4.4 above, when there are more cost-burdened renters, rental demand is less sensitive to changes in rents, and so a lower rental supply elasticity is required to match our property tax incidence target.

5.2. *Taxing imputed rents*

In our second experiment, we study the effects of taxing homeowners' imputed rents. Here, we treat these rents as another form of capital income and require homeowners to pay taxes in the amount of $\tau_k(p_r - \delta)h$ as in Nakajima (2020). This policy, which has been implemented by a number of European countries, has also been studied extensively (Gervais, 2002; Chambers et al., 2009; Floettoto et al., 2016; Nakajima, 2020).[24] As with repealing the MID, previous studies have all found long-run welfare gains from implementing this policy. Panel (b) of Table 5 shows the main results of this policy in our model, and panel (b) of Table 6 reports the distributional consequences. Broadly speaking, this reform would have qualitatively similar effects as MID repeal in all three calibrations, but these effects would be an order of magnitude larger.

5.2.1. *Benchmark calibration*

In our benchmark, homeownership would fall by 9.5 p.p. and house prices would fall by 8.0%. As before, the effect of the former on rents would outweigh the effect of the latter, causing rents to rise by 16.5%. This would hurt renters severely, especially those at the bottom of the income distribution, causing aggregate welfare to fall by 7.1%. The one difference between this reform and repealing the MID is that here, essentially all newborns would lose, even many of those at the top of the income distribution.

5.2.2. *Infinite rental supply elasticity*

In the calibration with a perfectly elastic rental supply, homeownership and house prices would fall substantially more than in the benchmark calibration, but because the rent-price ratio is independent of the quantity of rental housing that is supplied, rents would fall by 6.8%. Virtually all households would benefit, but households at the bottom of the income distribution would experience the largest gains. Qualitatively, the effects of this reform are identical to those of MID repeal in this calibration.

[23] Our model cannot deliver an increase in homeownership for any value of the rental supply elasticity. When we make the rental supply perfectly inelastic, homeownership still falls by less than 1p.p. when the MID is repealed.

[24] Imputed rents are taxed in Belgium, Iceland, Luxembourg, the Netherlands, Slovenia, Spain, and Switzerland.

5.2.3. No minimum rental size

In the calibration without a minimum rental size, homeownership would fall more than in the baseline and house prices would fall less, but as with MID repeal, rents would rise less due to this calibration's higher rental supply elasticity. Low- and high-income households would both lose, although not as much as in the benchmark, while households in the middle of the income distribution, for whom the benefits of lower labor income taxes would outweigh the higher housing costs, would gain. In the aggregate, welfare would rise by 0.45% and three-quarters of newborns would gain.

5.3. Sensitivity analyses

We have conducted several sensitivity analyses to demonstrate the robustness of our findings to important calibration choices and modeling assumptions. We limit our discussion of these analyses to their benchmark calibrations, as the goal is to verify whether repealing homeownership subsidies still reduces welfare in alternative setups (provided, of course, that these setups are able to account for the two key facts we have emphasized). Table 7 shows the aggregate welfare consequences of our policy experiments in these analyses. Additional details and results can be found in Appendix B.

5.3.1. Robustness to key factors

The first two sensitivity analyses focus on the parameters governing the rental supply elasticity and the prevalence of cost-burdened renters. In the first, we increase the rental supply elasticity by 50%, so that rents are less sensitive to demand than in our baseline. In the second, we reduce the minimum rental size by 50%, so that fewer renters are cost burdened and thus changes in rents are not as harmful. As the second and third columns of Table 7 show, MID repeal and taxing imputed rents would still generate sizeable welfare losses in both of these calibrations.

5.3.2. Higher aggregate housing supply elasticity

The third sensitivity analysis explores the role of the aggregate housing supply elasticity, which determines how much house prices respond to changes in overall housing demand. Here, we use Saiz (2010)'s estimate of 1.75 instead of Sommer and Sullivan (2017)'s estimate of 0.9. As shown in the fourth column of Table 7, eliminating homeownership subsidies would actually generate larger welfare losses in this calibration than in the baseline model. The economic intuition is that when the aggregate supply of housing is more sensitive to house prices, shifts in demand for housing cause smaller changes in house prices in equilibrium. This would make rents rise more in our experiments for two reasons. First, there would be less direct downward pressure on rents through the house price channel, i.e., the second term on the right-hand side of the rental management company's first-order condition (18) would fall less. Second, the smaller drop in house prices would make homeownership fall more in equilibrium, which would cause more upward pressure through the rental demand channel, i.e., the first term on the right-hand side of (18) would rise more. The larger increase in rents would hurt renters more, especially those at the bottom of the income distribution, which would magnify the aggregate welfare losses.

5.3.3. *Endogenous labor supply*

The fourth sensitivity analysis allows low-income renters to respond to higher rents by working more. In his version of the model, households in the bottom quintile of the labor income distribution choose endogenously how much labor to supply.[25] The results are shown in the fifth column of Table 7. Both experiments would still generate welfare losses in this version of the model, albeit smaller losses, as one might expect.

5.3.4. *Endogenous landlords*

In our fifth sensitivity analysis, we study a model in which rental housing is supplied by households who choose endogenously to become landlords, as in Chambers et al. (2009), Floettoto et al. (2016), and Sommer and Sullivan (2017), instead of by a representative management corporation. As the sixth column of Table 7 shows, this model performs similarly to the calibration of our baseline model with a perfectly elastic rental supply; welfare would rise in both experiments, just as other studies that have used endogenous landlord models have found. This is because this model has a very high rental supply elasticity. The share of property taxes borne by renters in this model is 94%, which is substantially higher than the value of 50% we targeted in the calibration of our baseline model. The elasticity of the aggregate rental supply curve in this model is 77, more than 54 times larger than the elasticity in our baseline model. Consequently, rents would fall in both experiments, leading to welfare gains for low-income renters. Endogenous landlord models in other studies also have very high rental supply elasticities. For example, as discussed in Section 2.1, the results in Floettoto et al. (2016) imply a rental supply elasticity of 38, almost than 30 times greater than our baseline model's elasticity.

5.3.5. *Rental vouchers instead of income tax cuts*

In our sixth sensitivity analysis, we study reforms in which the tax revenues generated by eliminating homeownership subsidies are distributed to renters in the form of rent subsidies, instead of being used to reduce all households' income taxes. The results are shown in the last column of Table 7. In the case of MID repeal, providing rental vouchers instead of reducing labor income taxes would indeed generate welfare gains instead of losses. Rents would rise more than in the baseline version of this experiment for two reasons. First, the rental subsidy makes renting more attractive than in the baseline, leading to a larger decline in homeownership, which in turn leads to a larger shift in the extensive margin of rental demand. Second, households who were already renters before the reform would demand larger units, leading to a larger shift along the intensive margin. Nevertheless, low-income renters would gain, leading to a gain in the aggregate and widespread approval.

[25]We do not allow other households to supply labor endogenously because our goal is to study the robustness of our results to additional margins on which low-income renters might be able to mitigate the effects of higher rents. Allowing all households to adjust their labor supply would lead rich households to also supply more labor to compensate for higher costs of owner-occupied housing. We do not have a fully fleshed-out model of the labor market in which both supply and demand for labor shift in response to shocks and the wage adjusts in equilibrium. Holding wages fixed in the face of material changes in aggregate labor supply would be unrealistic, and assuming an exogenous labor demand would lead to unrealistically large changes in wages that would work against the channel we want to focus on in this analysis.

In the case of the imputed rents tax, however, providing rental vouchers instead of tax cuts would still lead to welfare losses. In fact, the welfare losses would be even larger than in our main results. This is because homeownership would become very unattractive relative to renting, leading to much larger changes in homeownership and rents than in the baseline model. Moreover, the large decline in homeownership would greatly reduce the revenues raised by the imputed rents tax, which means that the vouchers would be fairly small in equilibrium. On the one hand, these results show that it may be optimal to eliminate homeownership subsidies like the MID as long as the revenues are redistributed in a way that offsets the general-equilibrium effects. On the other hand, they show that redistribution may actually lead to worse outcomes, even for households on the receiving end of that redistribution.

5.3.6. "Moving back home"

The last sensitivity analysis allows low-income households to respond to higher rents by moving in with their parents. In his version of the model, households in the bottom quintile of the labor income distribution can decide whether to remain in the housing market and pay the market rental price for housing services, or pay nothing to consume a small amount of housing services (i.e., live rent-free with their parents). We calibrate the amount of housing services that can be consumed without cost to match the fraction of households aged 26–34 who live with their parents in the data. The results are shown in the seventh column of Table 7. More young households live with their parents when the MID is repealed or imputed rents are taxed, but both experiments still generate similar welfare losses to the baseline model.

6. Conclusion

We study how homeownership subsidies affect renters in equilibrium and show that this channel plays an important role in determining the aggregate welfare implications of these policies. Two factors play critical roles in determining the magnitude of this effect: the price elasticity of the rental supply and the share of cost-burdened renters. The former determines how much rents respond in equilibrium to changes in demand for rental housing, and the latter determines how much changes in rents affect renters' welfare. When we calibrate our model to match empirical evidence on both of these factors, it predicts that repealing the MID and taxing imputed rents would reduce aggregate welfare and would particularly hurt low-income renters. When we omit either of these pieces of evidence from our calibration, the model predicts that these policies would increase welfare.

Previous studies, such as Gervais (2002), Chambers et al. (2009), Floettoto et al. (2016), Sommer and Sullivan (2017), Nakajima (2020), and Karlman et al. (2021), have found that these same tax reforms would be welfare-improving. We argue that this is because these studies are inconsistent with the empirical evidence about the key factors that we have emphasized. Except for Chambers et al. (2009), all have rental supply elasticities that are far higher than the evidence indicates, and only Gervais (2002) has a realistically high share of cost-burdened renters. We show that accounting for the evidence about both of these factors is crucial.

Our findings are particularly important for major metropolitan areas, where homeownership rates are lower and more renters are cost-burdened as compared to the national average. In New

York City, for example, the homeownership rate is less than one-third and more than one-quarter of renters are severely cost-burdened (NYU Furman Center, 2022). Oates and Fischel (2016) argue that the supply of rental housing is also less elastic in urban areas, which implies that rents in these areas are particularly sensitive to changes in demand. Thus, removing homeownership subsidies is likely to be substantially more harmful in these areas, both in the aggregate and for low-income renters in particular. Further, rents in communities across the United States have grown more quickly than incomes over the past two decades, leading to a large increase in the share of cost-burdened renters (Whitney, 2023). If this trend continues, eliminating homeownership subsidies would be even more harmful in the future.

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Table 1: Previous quantitative studies of homeownership policies

Study	Rental supply elasticity	Min. rental size target	MID repeal	Imputed rents tax
Gervais (2002)	Infinite	Rent/spending of lowest inc. quintile	Gain	Gain
Chambers et al. (2009)	Endog. landlords	No min. size	Gain	–
Floettoto et al. (2016)	Endog. landlords	No min. size	Gain	LR gain, SR loss
Sommer and Sullivan (2017)	Endog. landlords	Not reported	Gain	–
Nakajima (2020)	Infinite	No min. size	Gain	Gain
Karlman et al. (2021)	Infinite	Not reported	LR gain, SR loss	–

Table 2: Empirical evidence on the rental supply elasticity

Study	Estimate	Geography
(a) Renters' property tax incidence		
Carroll and Yinger (1994)	11%	Greater Boston region
Schwegman and Yinger (2020)	14%	New York State
Orr (1968)	30%	Greater Boston region
Orr (1970)	46%	Greater Boston region
Wiehe et al. (2018)	50%	United States
(b) Share of vouchers captured by landlords		
Sayag and Zusman (2020)	25%	Jerusalem
Viren (2013)	33%	Finland
Gibbons and Manning (2006)	40%	United Kingdom
Collinson and Ganong (2018)	46%	United States
Kangasharju (2010)	65%	Finland
Fack (2006)	78%	France
Susin (2002)	100%	United States

Table 3: Calibration

Parameter	Description	Value	Source
(a) Demographics and preferences (assigned)			
J	Lifespan	60	Live from 26-85
J_R	Retirement age	41	Retirement at age 66
σ	Risk aversion	2	Standard
$\{\xi_j\}_{j=1}^{J}$	Equivalence scale	Varies	AHS (2017)
$\{\phi_j\}_{j=1}^{J}$	Survival prob.	Varies	Arias (2014)
(b) Endowments (assigned)			
σ_x	Std. dev. of fixed effect	0.36	Guvenen et al. (2023)
ρ_z	Persistence of shock	0.90	Guvenen et al. (2023)
σ_z	Std. dev. of shock innovation	0.20	Guvenen et al. (2023)
$\{\zeta_j\}_{j=1}^{R}$	Life-cycle component	Varies	Guvenen et al. (2023)
$\theta(x)$	Prob. of wealth endowment at birth	Varies	SCF (2019)
$a_1(x)$	Wealth at birth conditional on endowment	Varies	SCF (2019)
ϑ	Surviving households' endowments	Residual	Equation (25)
(c) Taxes (assigned)			
τ_k	Capital gains tax rate	15%	Karlman et al. (2021)
τ_e	Personal exemption	$0.43 \times \tau_d$	U.S. tax code
ψ	Labor income tax progressivity	0.85	Heathcote et al. (2017)
$\kappa(x, z)$	Social security benefit	Varies	Guvenen et al. (2023)
(d) Housing market (assigned)			
τ_p	Property tax rate	1.0%	Sommer and Sullivan (2017)
δ	Depreciation rate	0.6%	Rosenthal (2014)
τ_b	Buying cost	2.0%	Gruber and Martin (2003)
τ_s	Selling cost	6.0%	Gruber and Martin (2003)
ϵ_2	Price elasticity of housing investment	1.9	Sommer and Sullivan (2017)
(e) Mortgages (assigned)			
r	Interest rate	3.0%	Kaplan et al. (2019)
Δ_m	Mortgage interest rate premium	1.0%	Kaplan et al. (2019)
λ_1	Max. LTV ratio	95%	US banking regulations
λ_2	Max. PTI ratio	39%	US banking regulations
ω_1	Origination cost	2.0% of avg. income	Kaplan et al. (2019)
ω_2	Prepayment penalty	3 months' interest	US banking practices
ν_1	Min. fraction of debt paid	1.7%	Karlman et al. (2021); Kaplan et al. (2019)
ν_2	Threshold for prepayment penalty	17.8%	US banking practices
(f) Jointly calibrated			
β	Discount factor	0.958	Mortgage debt/housing wealth = 0.35
γ	Utility weight on housing preferences	0.220	Avg. rent/income = 0.31
μ	Utility from bequests	43.0	65+ homeownership rate = 80.4%
τ_ℓ	Avg. labor income tax	0.766	Avg. labor income tax rate=22.4%
τ_d	Standard deduction	14.4% of avg. labor inc.	MID/GDP=0.41%
θ_1	Rental management cost level	$\theta_1 S^{\theta_2 - 1}/p_r$=46.2%	Rent/housing price=0.08
θ_2	Rental management cost convexity	2.54	Renters' tax incidence=50%
$\underline{h_r}$	Smallest rental	$0.40 \times$ avg. owned house size	Renters with rent/income$\geq$ 0.5=15.1%
$\underline{h_o}$	Smallest owned house	$5.03 \times \frac{\text{avg. owned house value}}{\text{avg. labor income}}$	Agg. homeownership rate=65.9%

Table 4: Non-targeted moments

Statistic	Baseline	Data	Source
Homeowners with a mortgage (%)	64.0	66.3	SCF (2019)
Homeowners with LTV≥80 (%)	13.3	10.7	SCF (2019)
Households who take the MID (%)	27.1	22	JTC (2010)
Share of rental vouchers captured by landlords (%)	55	25–100	See Table 2 panel (b)
Renters by income quintile (%)			
First	66.0	60.9	SCF (2019)
Second	36.6	44.8	SCF (2019)
Third	35.4	35.0	SCF (2019)
Fourth	28.6	20.4	SCF (2019)
Fifth	16.9	9.1	SCF (2019)

Notes: Share of rental vouchers captured by landlords is computed by analyzing a counterfactual equilibrium in which households in the bottom income quintile receive a transfer equal to $\min\{p_r h'_j(s), 5\%$ avg. rent$\}$. Share captured by landlords is measured as the change in aggregate rents collected by landlords divided by the aggregate voucher amount.

Table 5: Aggregate effects of housing policy changes

Calibration/ Experiment	House price (% chg.)	Rent (% chg.)	HO rate (p.p. chg.)	Welfare (% chg.)	Approval (%)
(a) MID repeal					
Baseline	−1.10	2.35	−1.46	−0.41	59.80
Infinite rental supply elast.	−1.70	−0.92	−2.50	0.93	100.00
No min. rental	−0.72	0.80	−1.62	0.14	85.39
(b) Imputed rents tax					
Baseline	−8.03	16.50	−9.52	−7.11	0.02
Infinite rental supply elast.	−12.67	−6.82	−18.38	3.14	98.15
No min. rental	−6.99	1.70	−10.32	0.45	74.46

Table 6: Welfare effects across the income distribution

Quintile	First	Second	Third	Fourth	Fifth
(a) MID repeal					
Baseline	−1.41	−0.05	0.03	0.08	0.15
Infinite rental supply elast.	1.40	0.78	0.73	0.71	0.61
No min. rental	0.13	0.24	0.20	0.16	−0.14
(b) Imputed rents tax					
Baseline	−16.60	−2.61	−1.79	−1.38	−1.57
Infinite rental supply elast.	5.27	2.63	2.40	2.26	1.26
No min. rental	−0.55	1.05	1.11	1.14	−0.19

Notes: Newborns are assigned to quintiles based on their income. Then, welfare changes for each quintile computed using equation (30), where integrals are taken over relevant subsets of the state space.

Table 7: Aggregate welfare consequences in sensitivity analyses

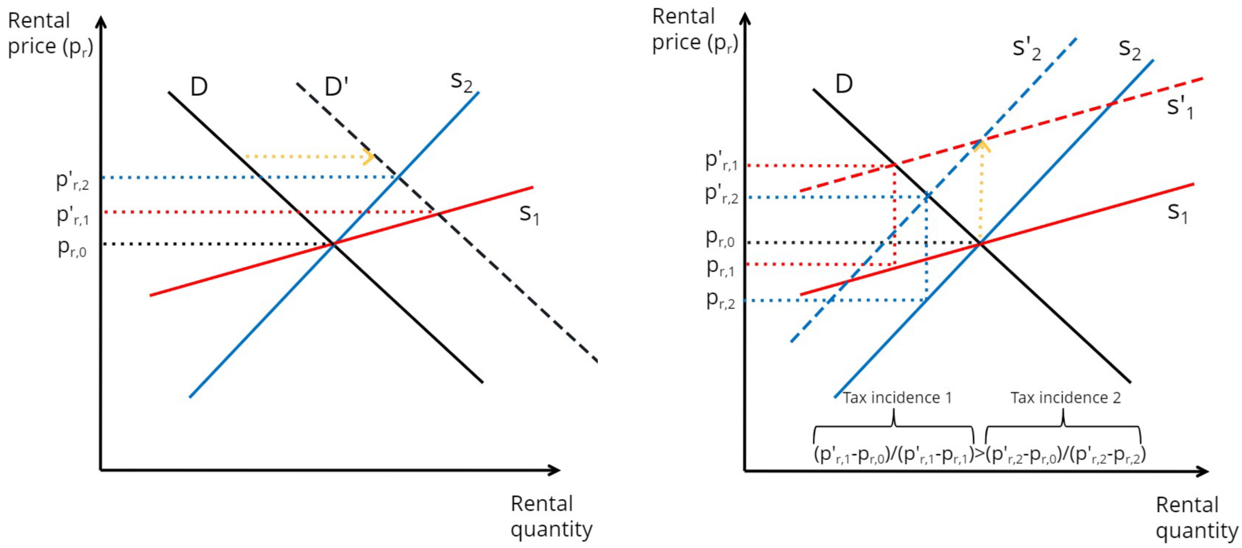
Experiment	Higher rental supply elast.	Smaller min. rental size	Higher housing supply elast.	Elastic labor	Endog. landlords	Rent vouchers	Moving back home
MID repeal	−0.23	−0.02	−0.59	−0.07	1.90	0.35	−1.35
Imputed rents tax	−3.83	−0.72	−7.95	−0.82	6.64	−7.68	−8.61

Notes: Higher rental supply elast.: θ_2 set so that rental supply elasticity is 50% higher than in baseline. Smaller min. rental size: $\underline{h_r}$ is 50% smaller than in baseline. Higher housing supply elast.: ϵ_2 set so price elasticity of aggregate housing supply is 1.75 as estimated by Saiz (2010). Elastic labor: households in bottom 20% of labor income dist. choose labor endogenously. Endog. landlords: rental housing supplied by households who choose endogenously to be landlords. Rental vouchers: changes in tax revenue are used to make lump-sum transfers to all renters. Moving back home: young households allowed to live rent-free "with their parents" and consume a small amount of housing services. In all sensitivity analyses, experiments conducted only in benchmark calibration that matches property tax incidence (except higher rental supply elasticity and endogenous landlord model) and share of cost-burdened renters. See Appendix B for more details on our sensitivity analyses.

Figure 1: Illustration of rental supply elasticity identification

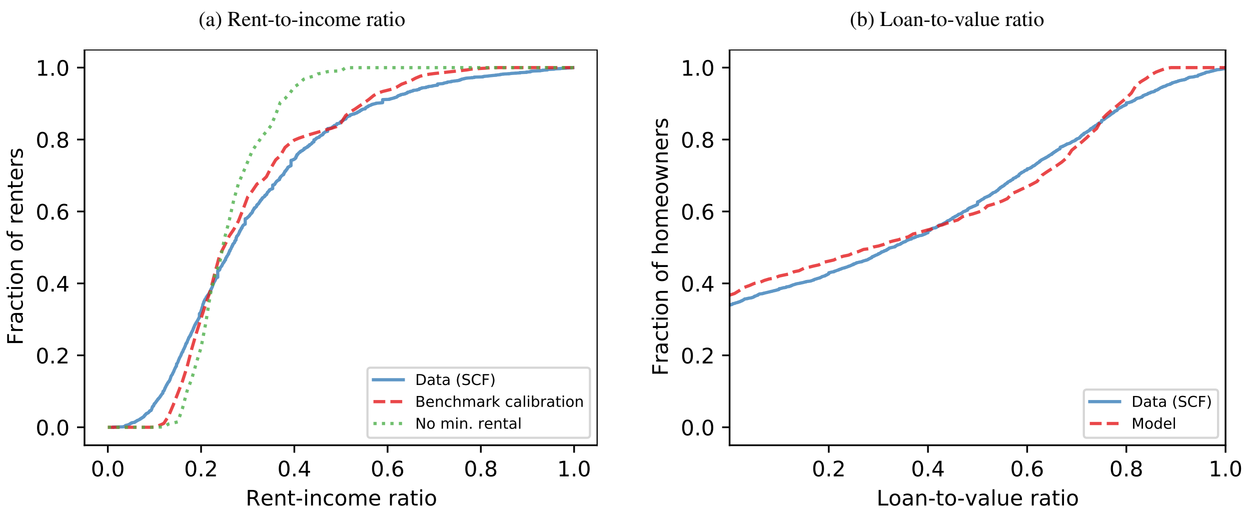
(a) Sensitivity of rents to demand

(b) Identification from property tax incidence



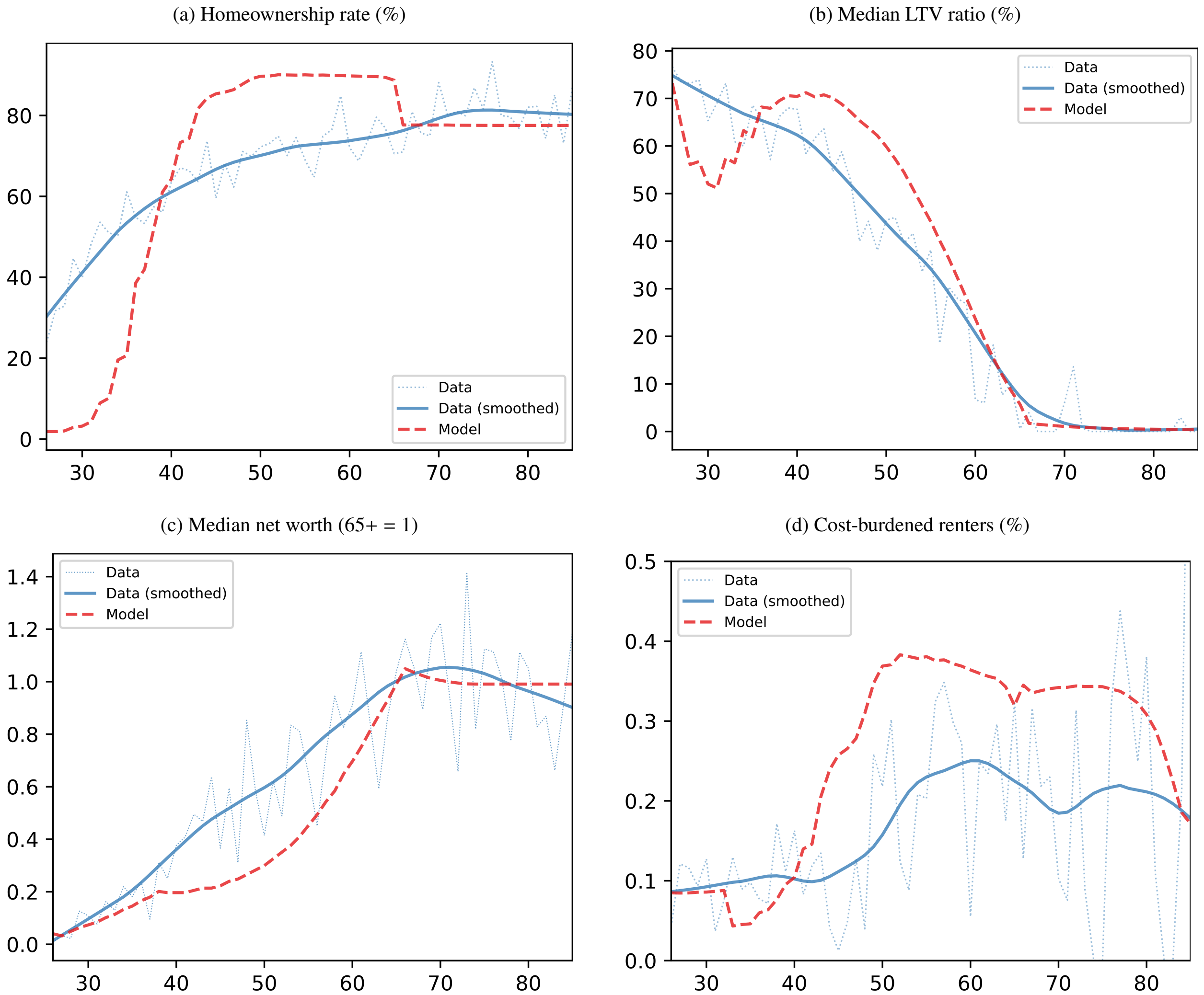
Notes: Panel (a): Illustration of how rental supply elasticity determines sensitivity of rents to shifts in rental demand. The x-axis represents the quantity of rental housing and the y-axis represents the rent per unit of rental housing. S_1 (red line) is high-elasticity supply curve. S_2 (blue line) is low-elasticity supply curve. Initially, demand is at D and rents are at $p_{r,0}$. Demand shifts from D to D', increasing rents to $p'_{r,1}$ (under S_1) or $p'_{r,2}$ (under S_2). Panel (b): Illustration of identification of rental supply elasticity from renters' property tax incidence. Demand is constant at D. Supply is initially at either S_1 (more elastic) or S_2 (less elastic) and rents are initially at $p_{r,0}$. Supply shifts by the amount indicated by the yellow arrow to either S'_1 or S'_2, increasing rents to either $p'_{r,1}$ or $p'_{r,2}$. Tax incidence measured as change in rents divided by length of yellow line.

Figure 2: Cumulative distribution functions in model vs. data



Notes: Panel (a): Cumulative distribution function of the rent-to-income distribution for renters. Solid blue line: 2019 SCF data. Dashed red line: our model's benchmark calibration. Dotted green line: our model's no-min-rental calibration. Panel (b): Cumulative distribution function of loan-to-value ratio for homeowners. Solid blue line: 2019 SCF data. Dashed red line: our model's benchmark calibration.

Figure 3: Life-cycle dynamics in model vs. data



Notes: Panel (a): Homeownership rate by age. Panel (b): Median loan-to-value ratio for mortgage holders by age. Panel (c): Median net worth by age, normalized so that the average of this statistic for ages 65 and over is equal to one. Panel (d): Fraction of renters in the total population of all households who spend more than 50% of their income on rent. Dotted blue lines: 2019 SCF data. Solid blue lines: SCF data smoothed using a Lowess filter to reduce spurious age-to-age fluctuations. Dashed red lines: our model's benchmark calibration.

Online Appendix: "Mortgage Interest Deductions? Not a Bad Idea After All'

Appendix A. Data and calibration procedure

This appendix describes data sources and the steps taken to calculate calibration moments using these data. Some of our assigned parameter values and calibration targets are taken directly from the literature. Most, however, we computed ourselves using microdata.

Appendix A.1. 2019 Survey of Consumer Finances

We use the 2019 Survey of Consumer Finances (SCF) to measure several of the targeted and non-targeted statistics that we use to calibrate and validate our model.[26] These statistics are measured as follows:

- The main variables we use are: age (AGE), tenure (HOUSECL), income (INCOME), rent (RENT), net worth (NETWORTH), house value (HOUSES), mortgage debt (MRTHEL).
- The homeownership rate is measured as the fraction of households with HOUSECL=1. We report the overall homeownership rate and the homeownership rate by age.
- The LTV ratio is computed as MRTHEL divided by HOUSES for households with HOUSECL=1. We compute the CDF, the median by age, and the fraction of homeowners with LTV>80%.
- The ratio of rent to income is measured as twelve times RENT divided by INCOME for households with HOUSECL=0. We compute the CDF, the overall average, and the average by age.
- The fraction of homeowners with a mortgage is measure as the fraction of households with HOUSECL=1 and MRTHEL>0, divided by the homeownership rate.
- To compute the fraction of renters by income quintile, we first assign households to quintiles of the variable INCOME. We then compute the fraction of households in each quintile with HOUSECL=0.
- The aggregate ratio of mortgage debt to housing wealth is measured as the sum of MRTHEL divided by the sum of HOUSES.

Appendix A.2. Procedure to calibrate rental supply elasticity

We use the following procedure to calibrate the parameter θ_2, which governs the elasticity of the rental supply, using the empirical evidence on the property tax incidence of renters:

1. Guess a value of θ_2.

[26] See https://www.federalreserve.gov/econres/scfindex.htm.

2. Calibrate the remaining parameters in panel (f) of Table 3 to match the remaining target moments.[27]

3. Increase the property tax on rental housing by 1p.p. Note that we do not change the property tax paid by homeowners. The change in property taxes only affects the rental corporation's first order condition (18).

4. Solve for the rental price $\hat{p}_r$ that clears the rental market, i.e., satisfies (23).

5. Compute the share of the property tax increase that is borne by renters as the change in rents divided by the size of the supply curve shift induced by the change in property taxes, i.e., $\frac{\hat{p}_r - p_r^*}{0.01 \times p/(1+r)}$, where p_r^* is the rental price in the initial calibrated equilibrium. Note that the change in property taxes is multiplied by the house price p and divided by $1 + r$ because this is the way these taxes show up in the rental management company's first order condition (18). I.e., $0.01 \times p/(1 + r)$ is how much the supply curve shifts in response to the property tax increase.

6. Check whether the property tax incidence is equal to, greater than, or smaller than 50%. If it is equal to 50%, then stop. If it is greater (smaller), then increase (decrease) θ_2 and go to step 2.

There is one subtlety worth mentioning here, which is that in step 4 we hold fixed house prices and do not clear the market for owner-occupied housing (22). The goal behind this is to hold fixed the rental demand curve as in panel (b) of Figure 1. If we allowed house prices to adjust, they would rise because owner-occupied housing becomes more attractive when rents rise. In equilibrium, this would shift rental demand inward, mitigating the slide along the rental demand curve caused by the rent increase. This means that the quantity of rentals demanded in equilibrium would be higher overall (i.e., it would fall less from the starting point), which would put more upward pressure on rents. Doing it this way would therefore require a lower supply elasticity to match a property tax incidence target of 50%. This would make our results even stronger—this is one more way that our approach is conservative.

Appendix B. Sensitivity analysis

This appendix provides additional details about the sensitivity analyses described in Section 5.3. Table B.8 reports the full set of results for all of these analyses. For brevity, we only conduct experiments using the benchmark calibration in each sensitivity analysis to verify that these experiment still yield welfare losses (or, in the case of the endogenous-landlord model, to show that the experiments yield gains).

[27]This is simpler than it sounds. As long as θ_1 is always chosen so that $\theta_1 S^{\theta_2 - 1}/q$ equals the same number for any value of θ_2, none of the other parameters/targets are affected. So really, only θ_1 needs to be adjusted at this step, and the other parameters in panel (f) of Table 3 can be calibrated independently.

Appendix B.1. Model with higher rental supply elasticity

In our baseline model, we calibrated the convexity of the rental management company's cost function, which governs the rental supply elasticity, to match a 50% property tax incidence for renters as used by ITEP. Here, we use a rental supply elasticity that is 50% higher than our baseline elasticity. Panel (a) of Table B.8 shows results for all the main variables of interest, as well as the welfare results reported in the main text of the paper. Both experiments still generate welfare losses in this calibration, albeit smaller losses than in the baseline calibration because rents rise less.

Appendix B.2. Model with smaller minimum rental size

In our baseline model, we calibrated the minimum size of a rental dwelling to match the share of cost burdened renters in the 2019 SCF data, which is 15.1%. Here, we use a minimum rental size that is 50% smaller than in our baseline calibration. Panel (b) of Table B.8 shows the results. Again, both experiments still generate welfare losses. The loss is small in the MID repeal experiment, but still quite sizeable in the imputed rents tax experiment.

Appendix B.3. Model with higher aggregate housing supply elasticity

In our baseline model, we used Sommer and Sullivan (2017)'s estimate of 0.9 for this elasticity. In this sensitivity analysis, we use Saiz (2010)'s estimate of 1.75 to calibrate ϵ_2. We hold all the other assigned parameter values listed in Table 3 fixed, except for the scale factor, ϵ_1 which must be recalibrated. Panel (c) of Table B.8 shows the results.

The welfare losses from our experiments are larger in this setup than in the baseline. The intuition for this is as follows. The higher housing supply elasticity means that the aggregate stock of housing is more sensitive to changes in prices, which in turn means that house prices are less sensitive to changes in demand for housing. Consequently, house prices fall less when the MID is repealed or imputed rents are taxed. A smaller drop in house prices has two effects. First, it makes homeownership fall more in equilibrium. Second, it makes rents rise more, both because there is less downward pressure on rents through the house price channel, but also because a larger decline in homeownership means a larger increase in demand for rental housing. This hurts renters more and makes the aggregate welfare outcome worse.

Appendix B.4. Model with endogenous labor supply

Here, we allow low-income households to choose how much labor to supply. We denote labor supply by n and leisure by ℓ. Households now have preferences

$$u_j(c, h, \ell) = \xi_j^{\sigma} \frac{\left(c^{1-\gamma} h^{\gamma}\right)^{1-\sigma}}{1-\sigma} + \nu \frac{\ell^{1-\rho}}{1-\rho}, \tag{B.1}$$

where ℓ is leisure, ν governs the share of leisure in flow utility, and ρ governs the Frisch elasticity. Labor income is now given by $y_j(x, z, n) = \zeta_j x z n$. Households have a total endowment of time that can be split between leisure and work denoted by $\bar{\ell}$, i.e., $n + \ell = \bar{\ell}$. We normalize $\bar{\ell} = 2.5$ so that a household that works one unit of time (as in the baseline model) uses 60% of their endowment for leisure, as in Guvenen et al. (2023). Only households with labor productivity fixed effects in the bottom 20% (i.e., $G(x) < 0.2$) can choose labor supply. For other households, we assume that $\ell = 1.5$ and $n = 1$ are fixed exogenously. We choose ν so that average labor supply across the entire economy is 40% of the time endowment and $\rho = 3$ so that the Frisch elasticity is one. The results are shown in panel (d) of Table B.8. The welfare losses are smaller than in the baseline, but the results are otherwise similar.

Appendix B.5. Model with endogenous landlords

Our endogenous landlord model is similar to Floettoto et al. (2016) and Sommer and Sullivan (2017). Rental housing is now supplied by homeowners who choose to rent out a portion of their houses. Specifically, a household that owns h' units of housing can choose to rent out $g \leq h' - \underline{h_r}$ units; just like renters, landlords must consume at least $\underline{h_r}$ units of housing services. As in the other models in this literature, landlords must pay a fixed cost of ϕ and earn rental income of $p_r g$. Rental income is taxed at the capital income tax rate τ_k. The fixed cost, depreciation, property taxes and mortgage interest on the rental property are allowed to be deducted. Thus, taxable rental income is $\tilde{y}_{\ell\ell}(h', g) = p_r g - \phi - pg(\delta + \tau_p) - m'(g/h')r$. We allow this taxable income to enter the PTI constraint, which means that landlords can obtain bigger mortgages than non-landlords. Only the portion of mortgage interest that is attributable to owner-occupied housing, $m'(1 - g'/h')r$, can be deducted from labor income taxes. The dynamic program in this model is

$$V_j(s) = \max_{c,a',o',h',n,m',g} \left\{ u_j(c, h' - g) + \beta\phi_j \int_{\mathcal{Z}} V_{j+1}(s')\, \mathrm{d}F(z, z') + \beta(1 - \phi_j) w_B(q') \right\} \tag{B.2}$$

subject to

$$\begin{aligned}
& c + a' + r_m m + (1 - o')p_r h + o\left[\delta + \tau_p + \mathbb{1}_{\{o'=0 \vee h' \neq h\}}\tau_s\right] ph + o'(1 + \mathbb{1}_{\{o=0 \vee h' \neq h\}}\tau_b)ph' + \vartheta(x, z) \\
& \quad = y_j(x, z) - \tau_j(x, z, o, h, m) + [1 + r(1 - \tau_k)]a + oph \\
& \quad + m' - m - n[\omega_1 + \tau_{pp}(m, 0)] - (1 - n)\tau_{pp}(m, m') \\
& \quad + p_r g - \mathbb{1}_{\{g>0\}}\phi - \tau_k \tilde{y}_{\ell\ell}(h', g) && \text{(B.3)} \\
& a' \geq 0, && \text{(B.4)} \\
& h' \geq o'\underline{h_o} + (1 - o')\underline{h_r} && \text{(B.5)} \\
& n \in \{0, o'\mathbb{1}_{\{j<j_R\}}\} && \text{(B.6)} \\
& g \in [0, o' \max(0, h' - \underline{h_r})] && \text{(B.7)} \\
& nm' \leq \lambda_1 ph' && \text{(B.8)} \\
& n[\tau_p ph' + \nu_1 m'] \leq \lambda_2[y_j(x, z) + ra + \tilde{y}_{\ell\ell}(h', g)] && \text{(B.9)} \\
& (1 - n)m' \leq (1 - \nu_2)m && \text{(B.10)} \\
& q' = a' + o'\left[ph' - m'\right] && \text{(B.11)}
\end{aligned}$$

We calibrate this model to match the same set of target moments as before, with two changes. First, the fixed landlord cost, ϕ, is chosen during our internal calibration procedure so that 10% of homeowners are landlords as estimated by Chambers et al. (2009). Second, and most important for our purposes, we no longer target the property tax incidence of renters because there is no parameter in this model that controls the aggregate rental supply elasticity. When we measure the aggregate supply elasticity in our calibrated endogenous-landlord model, however, we find an extremely high number. Near the calibrated benchmark equilibrium, the aggregate rental supply curve is extremely shallow: holding other prices fixed, a 1% increase in the rental price leads to a 77% increase in the quantity of rental housing supplied. This implies that renters' property tax incidence is 94%, far higher than the estimates in the literature reported in Table 2 and essentially the same in concept as the infinitely elastic supply case.

The supply elasticity in our endogenous-landlord model is similar to the elasticity implied by the results of Floettoto et al. (2016). In their experiment in which they eliminate the MID, rents rise by 2% and the stock of rental housing supplied in equilibrium rises by 76%, implying an aggregate rental supply elasticity of 38.[28] Most other papers that use the endogenous-landlord model like Sommer and Sullivan (2017) do not report enough information to make this calculation. The one exception is Chambers et al. (2009), who report that a 4% increase in rents increases supply by 6.3% in partial equilibrium, which implies a rental supply elasticity of only 1.6. We have tried many configurations of the endogenous-landlord model and cannot produce an elasticity anywhere near this low number. We can reduce the elasticity of the rental supply curve by taxing rental income at the same progressive rate as labor income, but this still implies a property tax incidence for renters that is far higher than in the data.[29]

Panel (e) of Table B.8 shows the results of our policy experiments in the endogenous-landlord model. Here, welfare would rise in both experiments and all newborn households would gain. This is because rents would fall due to a decline in homeownership. Overall, our results are quite similar qualitatively to those of Floettoto et al. (2016), and in some respects they are fairly similar quantitatively as well. Note that rents move almost one for one with house prices, which is another way of seeing that the rental supply elasticity is close to infinite.

We have also attempted to build a version of the endogenous-landlord model with a lower aggregate supply elasticity generated by a convex rental management cost as in our baseline model. However, because (i) each individual landlord supplies small amounts of rental housing relative to the aggregate quantity supplied, and (ii) aggregate supply changes are driven by the extensive margin as well as the intensive margin, we have found that it is not possible to identify the landlord-level management cost convexity from the aggregate property tax incidence. We speculate that one needs to model a management cost that depends on the aggregate quantity supplied, not the individual, landlord-level quantity. For example, one might be able to generate a low aggregate rental supply elasticity if they modelled a rental management company that landlords pay to manage their properties, and this company has increasing marginal costs. This would create an externality in the rental market, however, because individual landlords would not take into account how their choices affect the aggregate management cost. Grappling with this issue is outside the

[28] In their experiment, the aggregate stock of housing, the house prices, and the landlordship rate do not change much, implying that the rental supply curve does not shift much. However, if anything, it is likely that the rental supply curve shifts inward because the homeownership rate falls. If so, this would mean that the supply elasticity in their model is even higher than we have calculated.

[29] Moreover, in this version of the model the rental supply increases dramatically more in our policy experiments. The net effect is that rents fall even more than in the infinite-elasticity corporate model, leading to even larger welfare gains.

scope of our paper.

Appendix B.6. Model with rental vouchers instead of tax cuts

Here, instead of using additional tax revenues to lower labor income taxes, we assume that renters receive a lump-sum transfer equal to the maximum of a scalar v and their rental expenses. Thus, the budget constraint now becomes

$$\begin{aligned} c + a' + r_m m + (1 - o')p_r h' + o\left[\delta + \tau_p + \mathbb{1}_{\{o'=0 \vee h' \neq h\}}\tau_s\right] ph + o'(1 + \mathbb{1}_{\{o=0 \vee h' \neq h\}}\tau_b)ph' \\ = y_j(x, z) - \tau_j(x, z, o, h, m) + [1 + r(1 - \tau_k)]a + oph + \vartheta(x, z) + (1 - o')\min[v, p_r h'] \\ + m' - m - n[\omega_1 + \tau_{pp}(m, 0)] - (1 - n)\tau_{pp}(m, m'), \end{aligned} \tag{B.12}$$

where the last term on the second line represents the voucher. The government's budget constraint now has an additional term, $\sum_{j=1}^{J} \int_S (1 - o_j'(s)) \min[v, p_r h_j'(s)]$, on the expenditure side. When we calibrate the model to the current tax code, we set $v = 0$, and then in our policy reforms we choose v to ensure that the government's budget constraint continues to hold.

The results are shown in panel (f) of Table B.8. In the case of MID repeal, welfare now would rise. The homeownership rate would fall more because renting would be now more attractive relative to the experiments in the baseline model, so house prices would fall more and rents would rise more. Nevertheless, the vouchers would be enough to make renters better off. In the case of the imputed rents tax, however, the welfare outcome would actually be worse than in the baseline model. This is because the imputed rents tax would make homeownership much more costly than the MID repeal, and when combined with a rental subsidy, this reform would dramatically reduce the homeownership rate. House prices would fall far more than in the baseline, but the massive decline in homeownership would lead to a similarly massive increase in demand for rental housing that would cause rents to rise sharply in equilibrium. The vouchers would simply not be enough to compensate renters for this increase, and this is compounded by the fact that the tax would raise much less revenue than in the baseline experiment in which labor income taxes are cut instead, because there are fewer homeowners left to pay it. Lastly, since more households would rent, the smaller revenues would be spread out over many more renters, making them small per renter.

Appendix B.7. Model with a "moving back home" channel

In our last sensitivity check, we study whether allowing cost-burdened households to move in with their parents would reverse our results. The idea here is that if cost-burdened households could move back in with their parents, they could escape the increases in rents, thus invalidating the main channels highlighted in this paper.

To include a "moving back home" option in our model, we add one more housing option $\hat{h}_r < \underline{h}_r$ for households aged 26–34 in the bottom quintile of the income distribution. Households who choose to move in with their parents pay no rent, but incur a utility cost which is captured by the assumption that $\hat{h}_r < \underline{h}_r$. We recalibrate the model in the same as as before, and additionally choose $\hat{h}_r$ to match the percentage of 26-34 year-olds who live with their parents, which is 15.1%.[30] We

[30] See https://www.statista.com/statistics/1074730/living-arrangements-30-year-olds-usa/.

remove households who live with their parents from the state-space distribution for the purposes of computing aggregate statistics such as the homeownership rate and the fraction of cost-burdened renters.

We show the results for this set up in panel (g) of Table B.8. As one would expect, when rents go up more households choose to live with their parents; when MID is repealed, 17.4% of households choose to live with their parents instead of 15.1% as in the benchmark, and when imputed rents are taxed 32.4% choose to do so. All of our other results are similar to our baseline's, although welfare losses are lower; moving back home alleviates households' financial burden, but households that move back with their parents still have to pay with their utility to take this option.

Table B.8: Detailed results of sensitivity analyses

Calibration/ Experiment	House price (% chg.)	Rent (% chg.)	HO rate (p.p. chg.)	Welfare (% chg.)	Approval (%)
(a) 50% higher rental supply elasticity					
MID repeal	-1.17	1.90	-1.74	-0.23	91.67
Imputed rents tax	-9.02	10.49	-10.98	-3.83	1.12
(b) 50% smaller min. rental size					
MID repeal	-0.55	1.43	-0.94	-0.02	77.41
Imputed rents tax	-6.89	6.90	-8.73	-0.72	54.67
(c) Elastic housing supply					
MID repeal	-0.78	2.74	-1.55	-0.59	2.97
Imputed rents tax	-7.69	17.53	-14.99	-7.95	0.02
(d) Endogenous labor supply					
MID repeal	-0.90	1.88	-1.27	-0.07	59.80
Imputed rents tax	-7.41	9.86	-8.23	-0.82	0.16
(e) Endogenous landlords					
MID repeal	-2.28	-2.66	-5.57	1.90	100.00
Imputed rents tax	-13.94	-14.81	-22.09	6.64	100.00
(f) Rent vouchers instead of income tax cut					
MID repeal	-1.90	4.00	-2.43	0.35	85.74
Imputed rents tax	-17.08	40.30	-20.71	-7.68	0.00
(g) "Moving back home"					
MID repeal	-1.35	2.34	-1.79	-0.26	2.97
Imputed rents tax	-8.61	12.63	-9.99	-2.51	0.02